Inst. Man. No. TP450A- 8112
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INSTRUCTION MANUAL
MODEL TP450A
THERMOSTREAM® SYSTEM

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ADDENDUM

STARTING INSTRUCTION
TP40, TP042, TP450

This procedure should be followed when starting any of the systems listed above. It is especially important when the system is operated in an environment having high relative humidity or when the system has been turned off for several hours.

1. Immediately upon turning the system power ON, set the temperature to +100°C and turn the Air Flow ON.
2. Allow the system to run at 100°C for one minute. This will eliminate any moisture that could cause a "freeze up" in the nozzle of the Primary Heat Exchanger.
3. After one minute, turn OFF the Air Flow and allow the system to run for approximately fifteen minutes before turning the Air Flow ON again. This will enable the second stage of the Heat Exchanger to reach a sufficiently low temperature to allow proper operation of the system.

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model TP450A ThermoStream® System (Figure 1) is a cabinet-mounted temperature control system that provides a wide-range (-60° to +150°C), programmable thermal environment for the controlled testing of semiconductors, IC's, or other such components and circuits that the user desires to test at precisely controlled, repeatable temperatures. The system provides precision temperature control to within ±1% of the digital temperature read-out or ±1°C, whichever is greater, over the full range of -60° to +150°C. In addition to broad range and high accuracy, the Model TP450A ThermoStream System also provides fast response time with near linearity of response throughout its range.

The Model TP450A ThermoStream System is comprised of three basic components: a digital controller unit (top right of Figure 1), a thermal generator section (base unit, Figure 1), and a primary heat exchanger and tester, which is available in two versions: a bench-mounted unit, as shown in Figure 1, and a floor-mounted unit, as shown in Figure 2. The system operates from standard 115 VAC, 50-60 Hz power sources (220 to 240 VAC options are available.

A source of dry gas is also required for system operation, but this is not supplied as part of the system. The thermal environment for the testing of components and circuits is accomplished by cooling and heating the dry gas stream in the primary heat exchanger to provide the controlled temperature.

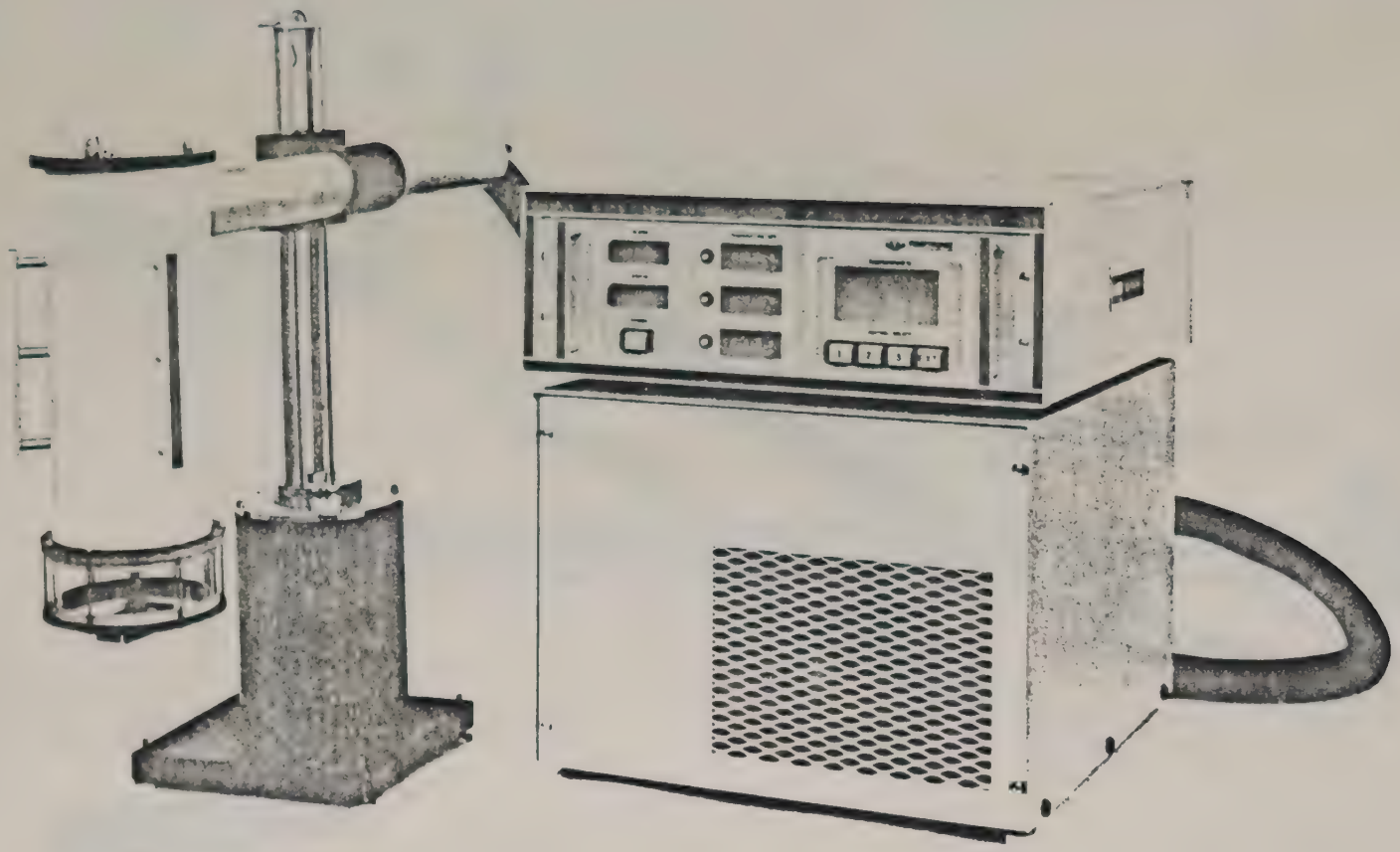


Figure 1. Model TP450A ThermoStream System with bench-mounted heat exchanger.

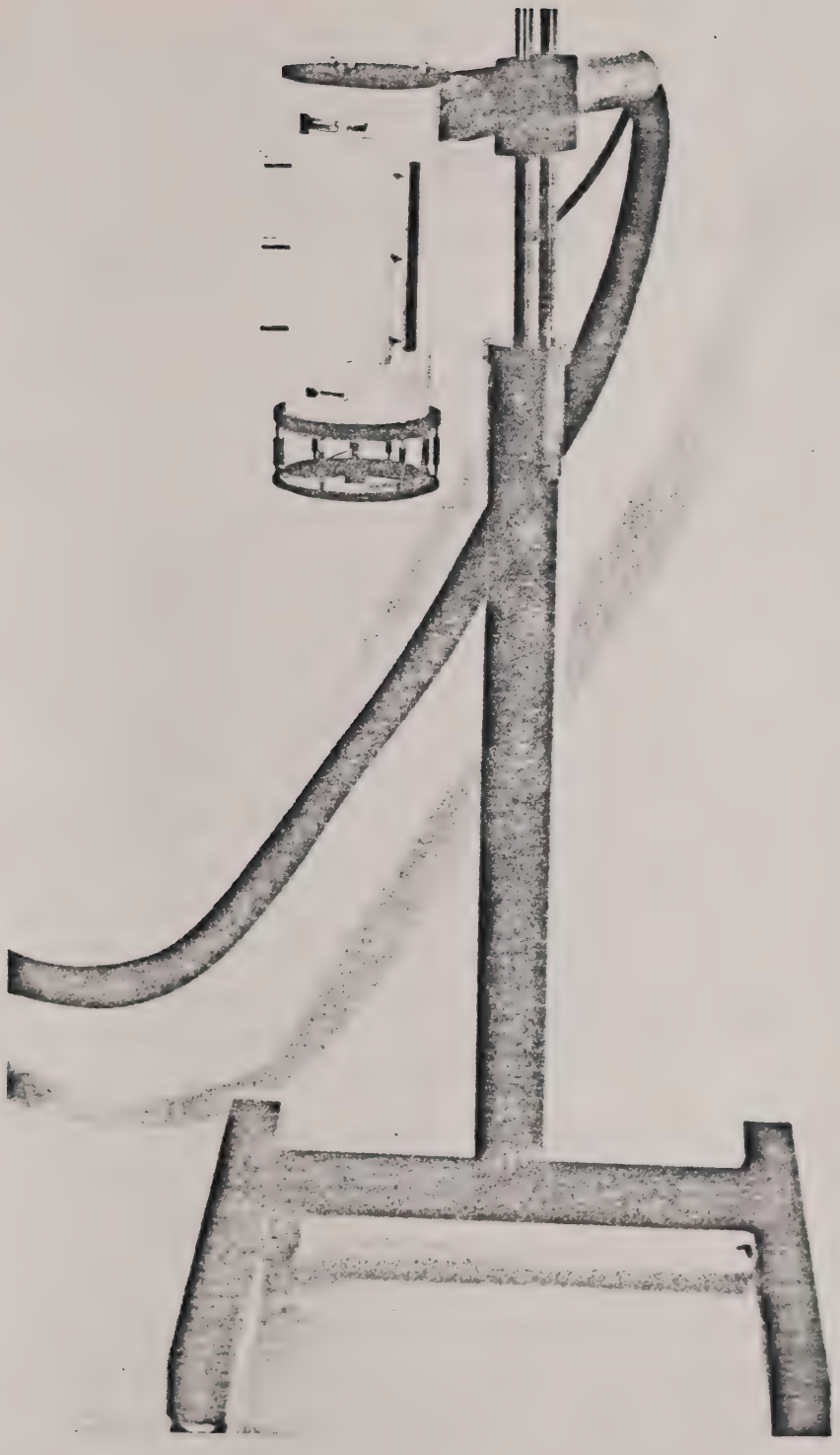


Figure 2. Model TP450A ThermoStream System floor-mounted heat exchanger.

The Model TP450A System can be operated in two modes: local or external. In the local mode, the operator presets a desired temperature on any one of three channels by means of pushbutton selector switches. A continuous digital readout of the temperature of the dry gas stream is up-dated at a rate of approximately twice per second.

In the external mode, the operator must provide the necessary external reference data (binary coded decimal), including a data-ready signal, through a cable connection that is available for this purpose at the rear of the digital controller unit. Any TTL/DTL compatible signal generator device can be used, provided that the required plug connection and jumpering are accomplished, as described in Section 5.2.5.

1.2 FUNCTIONAL DESCRIPTION OF COMPONENTS

1.2.1 Digital Controller Unit

The digital controller unit contains the bulk of the controls and indicators associated with the Model TP450A ThermoStream System, and is the logic element that controls the operation of the system. The digital controller is used to turn the system on, provide signals to interrogate the dry gas stream, compare the gas stream temperature with the set temperature, and drive the thermal generator up or down to bring the gas stream temperature into conformance with the set temperature.

In addition to these control functions, the digital controller logic is also used to drive the various indicator and warning lights, which include:

a. the momentary-contact, pushbutton switch/indicator (POWER) that is used to turn on the system.

b. four pushbutton switch indicator lights that show which of the four channels - three local and one external - is active.

c. three indicator lights adjacent to the data selector switches that show which of the three set temperatures is the active channel.

d. a combined switch (momentary reset) and alarm light (OVERHEAT) which signals that the dry gas stream temperature has exceeded the system upper limit (+160°C); this causes immediate removal of power from the primary heat exchanger.

e. an indicator light (OUT OF RANGE) which signals that the set temperature is beyond the range of the system (-60° to +160°C).

f. a status indicator light (NO FLOW) which signals that there is no gas flow through the primary heat exchanger.

g. a status indicator light (AT TEMP) which signals that the dry gas stream has reached the set (internal or external) temperature; this latter signal will occur when the gas stream is at or within ±2°C of the set temperature.

1.2.2 Thermal Generator

The thermal generator (Figure 3) consists of two functional elements, the power control section and the secondary heat exchanger, which is a cascade refrigeration system. The power control section is mounted within a separate frame and the entire unit can be pulled out for servicing by removing the rear panel screws.

WARNING

The line voltage and the voltages across the terminals of several components represent a potential lethal hazard. Under no circumstances should persons untrained in electronics attempt to gain access to the interior of the TP450A ThermoStream System.

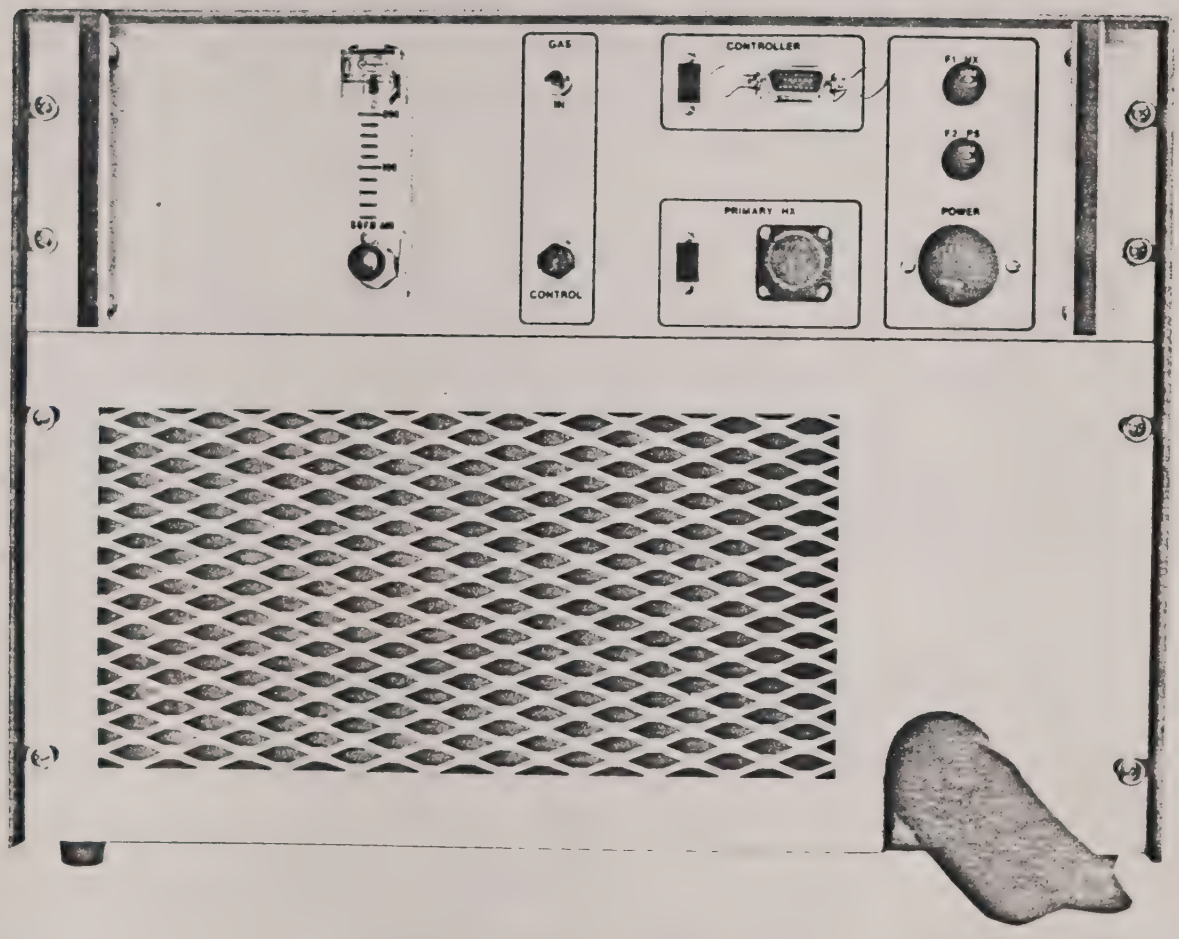


Figure 3. Thermal generator section, rear view.

The functional elements of the power control section consist of four relays, a flow switch, a solenoid valve, and a flow regulator/indicator. The unit also mounts two fuses, and separate power and signal distribution plugs. In addition to providing AC power to the primary heat exchanger during heating, the power control unit also provides power to the electrical elements (compressors, relays, solenoids, and switches) within the secondary heat exchange section.

In normal operation, the power control unit provides the power needed to heat the dry gas stream to the set temperature and to maintain it at that set temperature. If the gas stream temperature is below that of the set temperature, the power control drives a heater in the primary heat exchanger. If the gas stream temperature is above that of the set point, the primary heat exchanger heating is turned off and the cooling provided by the secondary heat exchange section cools the dry gas stream.

CAUTION

Because of surge currents developed when the secondary heat exchanger starts, the separate three-wire AC line to the power control should always be No. 12 or larger.

1.2.3 Primary Heat Exchanger

Functionally, the primary heat exchanger is the interface between the items being tested and the TP450A System. The temperature-controlled environment is obtained in the dry gas stream that impinges on the component being tested. The composition of the primary heat exchanger and the placement of the internal sensor are such that the gas stream temperature is maintained within $\pm 2^{o}C$.

The primary heat exchanger requires considerable attention. The following warnings and cautions are provided.

WARNING

Avoid contacting the gas stream of the primary heat exchanger. The extreme temperatures are hazardous.

WARNING

Periodically check the integrity of the primary heat exchanger connections, particularly the refrigerant line. The discharge of coolant from a faulty line could be hazardous.

CAUTION

Always install the Model TP450A System in a manner that will insure a minimum bend radius of 4 inches in the primary heat exchanger refrigerant line when the primary heat exchanger is in position.

CAUTION

The Pyrex material of the thermocap is delicate and can be broken with improper or careless handling. If broken, the Pyrex cylinder must be replaced.

1.2.4 Dry Gas Source

A source of dry gas with a pressure of 30 psi and a flow rate of 3.0 cubic feet per minute is required to provide the controlled thermal environment for component and circuit testing. The gas is cooled and heated in the primary heat exchanger to the controlled temperature. A dry gas - that is, a gas with a dew point of -70°C or colder - must be used or condensation and ice will form and restrict or block the gas stream passageway into the primary heat exchanger. The dry gas source is not provided as part of the TP450A ThermoStream System and must be supplied by the user.

1.3 POWER REQUIREMENTS

1.3.1 Normal Operation

An external power source of 115 VAC, 60 Hz, is required to operate the Model TP450A ThermoStream System (220 to 240 VAC options are available). Because of the surge currents that occur when the cooling elements start, it is recommended that the two separate input power connections be made to two independent lines, thereby minimizing the effects of noise on the digital controller logic.

1.3.2 External Set-Temperature Connection

The TP450A ThermoStream System can be used with an external set-temperature connection. The input signal from the external element must be TTL/DTL compatible. Connection is made at the rear of the digital controller with a Cinch 57-30360 type plug or equivalent and a closure from pin 18 to pin 36.

1.4 SUMMARY OF SYSTEM CHARACTERISTICS

As an aid to preinstallation planning, a summary of the Model TP450A ThermoStream System physical characteristics and power requirements is given in Table 1.

Table 1. Summary of system characteristics.

Unit	Dimensions and Weight				Power Requirements*		
	Height (in.)	Width (in.)	Length (in.)	Weight (lb)	Voltage (VAC)	Hertz	Power Level (amp)
Digital Controller	7-1/2	20-1/2	22-1/2	18	115	60	1/2
Thermal Generator	15	20-1/2	22-1/2	117	115	60	10

*Power Requirements

Standard Specification: 115 VAC Nominal, 105-125 Range, 50/60 Hz
220-240 Option: 230 VAC Nominal, 220-240 Range, 50/60 Hz

SECTION 2

INSTALLATION

2.1 UNPACKING

The Model TP450A ThermoStream System is shipped in one container. It is suggested that the packaging material be retained and stored in the event that the system has to be reshipped at a future time.

When received, the package should be examined for any signs of mishandling or damage during the shipment.

NOTE

If there are any obvious signs of damage when the package is received, contact the carrier immediately and do not proceed with the installation.

After the equipment has been unpacked, the following visual inspections should be made:

1. Verify that all digital controller alarm and switch cover plates (1, 2, 3, EXT, AT TEMP, POWER, ALARM, etc.) are in place and intact.
2. Insure that cable connections and pins appear straight and aligned on each cable.
3. Check that the digital thermometer cover is intact and in place.
4. Verify that all cabinet element hold-down screws are snug.

5. Insure that the primary heat exchanger refrigerant line is uniformly cylindrical along its entire length.

6. Verify that all fuses are in place and are sound. There are three fuses in the system: a 1-amp fuse at the rear of the digital controller, and a 10-amp (F2) and a 15-amp (F1) slo-blow fuse at the rear of the power control section of the thermal generator.

2.2 INSTALLATION

In planning the installation of the TP450A ThermoStream System, the following provisions should be considered:

1. The digital controller should be mounted in a position that will allow convenient viewing and easy access to both the front panel controls and the rear panel connections.

2. The thermal generator should be placed on a stand that is stable and capable of supporting 150 lbs.

3. The thermal generator should be oriented such that the refrigerant line connection from the primary heat exchanger and connection to the power control panel can be made easily.

4. Sufficient air flow to the front and rear of the thermal generator should be assured.

5. The primary heat exchanger and thermal generator placement must be such that the primary heat exchanger refrigerant line is not subjected to excessive bending. The units must be close enough so that the signal and power connection cords can be connected.

6. The primary heat exchanger can be oriented and leveled by a number of adjustments, such as swing, tilt, level, in and out, and up and down. The controls for these adjustments are indicated in Figure 4.

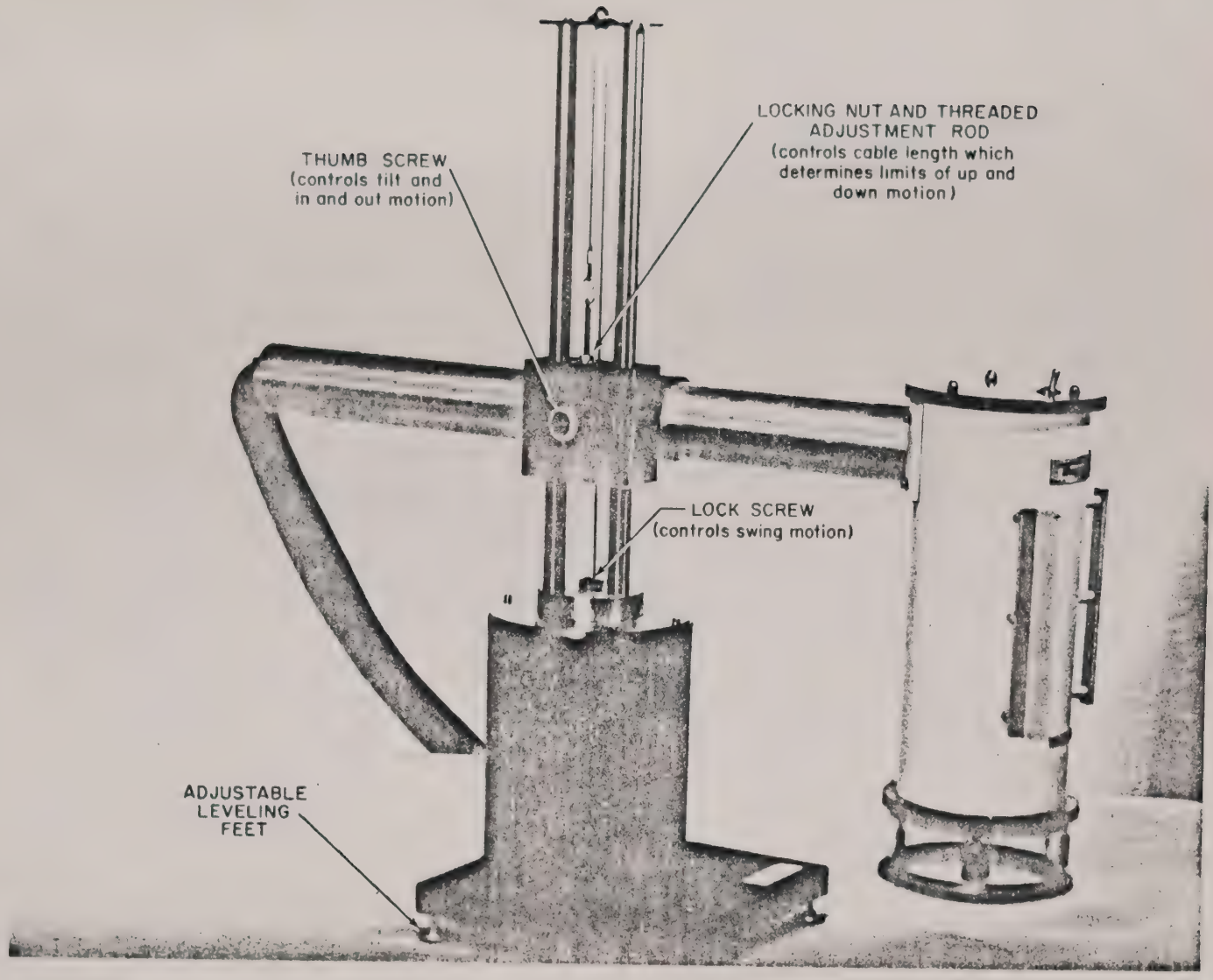

LOCKING NUT AND THREADED ADJUSTMENT ROD
(controls cable length which determines limits of up and down motion)
THUMB SCREW
(controls tilt and in and out motion)
LOCK SCREW
(controls swing motion)
ADJUSTABLE LEVELING FEET

Figure 4. Primary heat exchanger positioning and orientation adjustments.

7. There should be convenient access to two separate 115 VAC line connections without use of excessively long extension cords.

2.3 INTERCONNECTIONS

Interconnection of the Model TP450A ThermoStream System elements is a routine procedure wherein the supplied cables are merely attached to their mating connectors for the desired use, as shown in Figure 5. There are two areas - the two twin-bladed plugs (temperature sense, digital controller rear panel, and power control panel) - where care must be exercised. The following sequence is suggested:

1. Connect the primary heat exchanger power cable (7-pin connector, Amphenol MS3102A-16S-1P).
2. Connect a two-bladed thermocouple plug (attached to the power cable) into the power control panel receptacle.
3. Connect a two-bladed thermocouple plug from the power control to the rear of the digital controller.

CAUTION

The thermocouple plugs can be inserted incorrectly if forced. The larger blade goes into the bottom slot; the smaller into the top slot.

4. Connect and latch the interface signal cable (14-pin, Cinch 57-40/40) between the power control rear panel and the digital controller rear panel.
5. Connect the digital controller power cable to the unit and to a suitable power outlet.
6. Connect the thermal generator power cable to the power control panel and to a suitable power outlet.
7. Connect a dry gas supply to the power control unit.

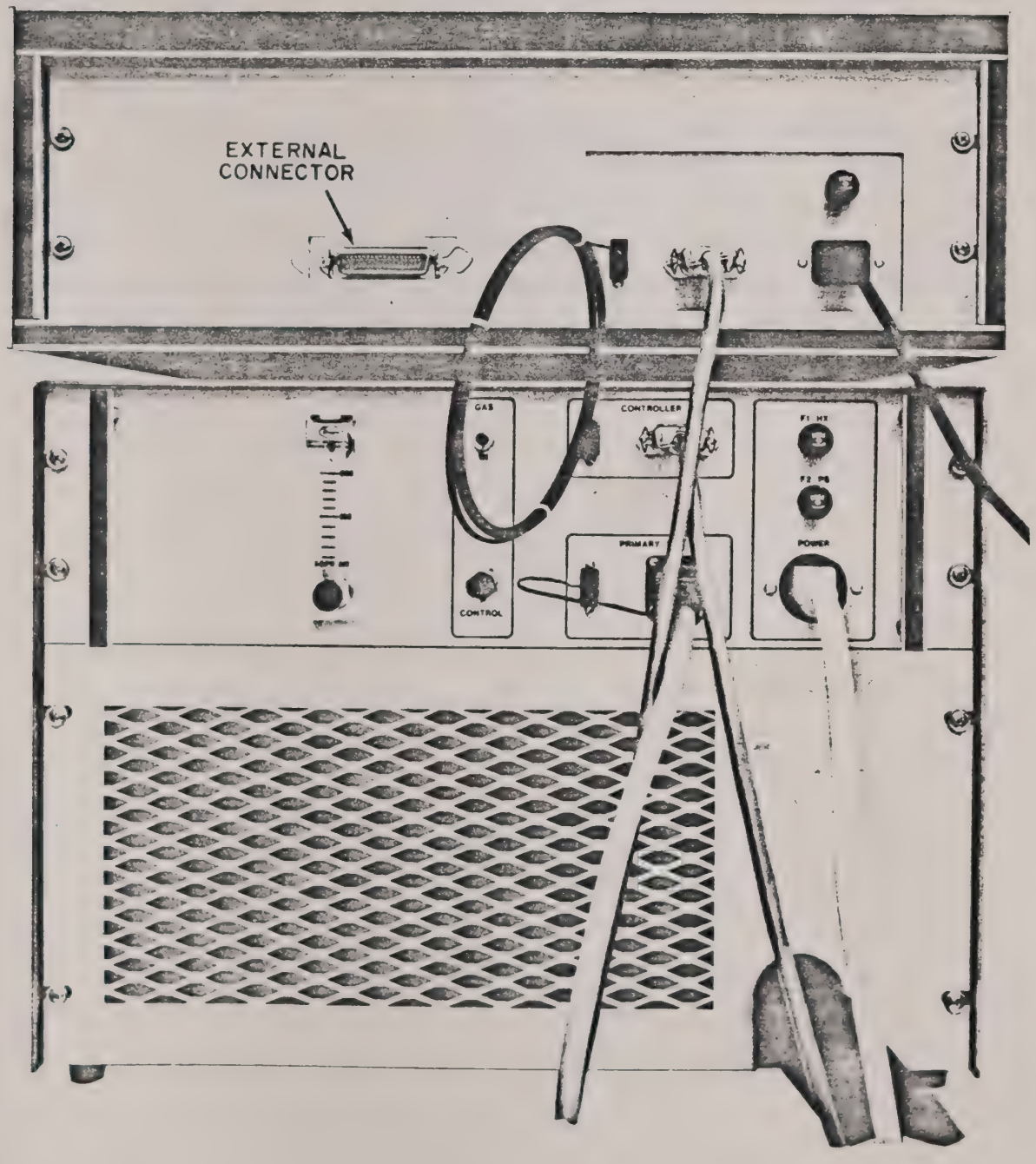


Figure 5. System interconnections.

After the units have been positioned and interconnected, the system is ready to be checked out and operated as described in Section 3.

2.4 REPACKAGING

If it should be necessary to ship the Model TP450A Thermo-Stream System to some other site or to return it to the manufacturer for repair, the packaging used for shipping can be reused. All of the equipment should be wrapped with soft protective material to prevent breakage or scratching, and should be banded to the pallet to prevent movement of the equipment during transportation.

SECTION 3

OPERATION

3.1 CONTROLS AND INDICATORS

Most of the switches, controls, and indicators associated with the operation of the Model TP450A ThermoStream System are located on the front panel of the digital controller. A switch to turn the gas flow on and off, and a gas flow regulator are located on the primary heat exchanger and the power control unit, respectively.

3.1.1 Digital Controller Controls and Indicators

The digital controller controls and indicators are shown in Figure 6 and are keyed by index numbers to Table 2, which gives descriptions of their functions.

Table 2. Digital controller front panel controls and indicators.

Index Number	Name	Description
1	POWER	Turns system power on and off. When depressed, switch illuminates to indicate that power is on.
2,3,4,5	CONTROL SELECT selector switches	Pushbutton switches for selecting three internal set temperature channels or external channel. Switch illuminates when depressed, with corresponding TEMPERATURE SET indicator (index Nos. 9, 10, or 11) also illuminating to indicate selected set temperature. Depressing EXT switch activates external temperature control.

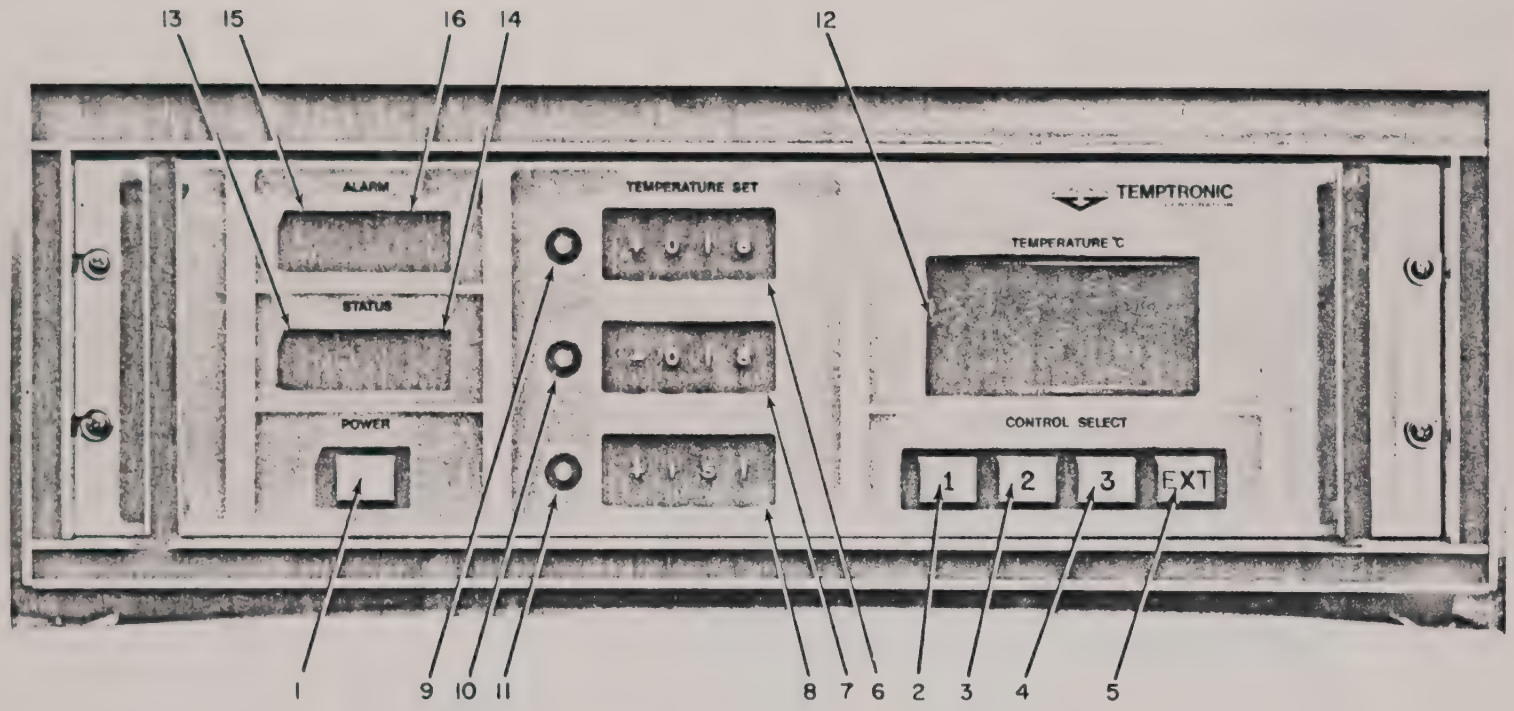


Figure 6. Digital controller front panel controls and indicators.

Table 2. Digital controller front panel controls and indicators. (Continued)

Index Number	Name	Description
6,7,8	TEMPERATURE SET selector switches	Pushbutton selector switches for selecting desired temperatures on three internal channels. Three-channel option enables operator to preset three temperatures of interest for rapid operation.
9,10,11	TEMPERATURE SET indicators	Indicator lights that signal which one of three internal channels is providing the temperature set point.
12	TEMPERATURE ^{o}C	Digital readout of temperature of dry gas stream. Readout is up-dated approximately twice per second.
13	NO FLOW	Indicator illuminates to indicate that dry gas is not flowing.
14	AT TEMP	Indicator illuminates when dry gas stream temperature is within $\pm 2^{o}$ of the set temperature.
15	OVERHEAT	Indicator/switch illuminates if dry gas stream temperature exceeds operating limit of system (+160°C). If this occurs, power is automatically removed from heater. Heater power is restored when switch is depressed.
16	OUT OF RANGE	Indicator illuminates when selected set temperature is beyond the upper (+160°C) or lower (-60°C) limits of the system. Primary use of OUT OF RANGE indicator is to alert operator when system is in external mode, with no visible indication of set temperature.

3.1.2 Primary Heat Exchanger Dry Gas On-Off Switch

A switch on the thermocap of the primary heat exchanger is used to turn the flow of gas through the primary heat exchanger on and off. The position of the switch is shown in Figure 7.

3.1.3 Power Control Gas Flow Regulator

A gas flow regulator on the panel of the power control unit is used primarily to control the volume of dry gas flow through

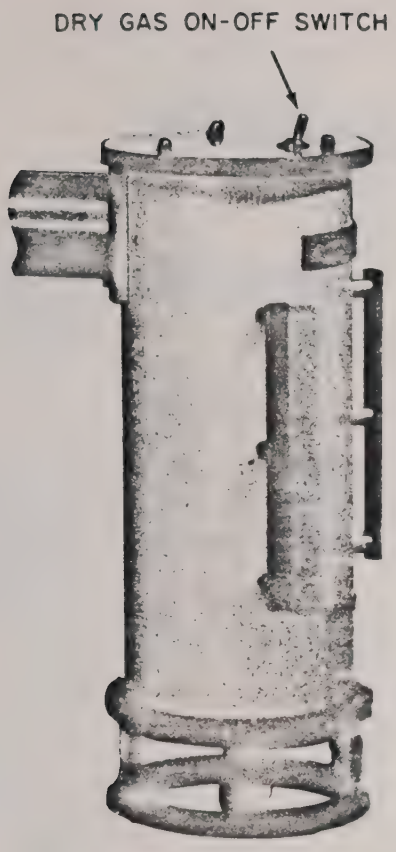


Figure 7. Primary heat exchanger dry gas on-off switch.

the primary heat exchanger. Normally, the gas flow regulator is adjusted to the setting prescribed by the specification sheet that is provided with each system and remains permanently at that setting. The position of the gas flow regulator is shown in Figure 8.

3.1.4 Remote Dry Gas On-Off Switch

A connector on the panel of the power control unit can be used, if desired, for attaching a cable-mounted switch to turn the gas flow on and off from a more convenient location. A contact closure between pins A and B on this connector turns the gas flow on. The position of this connector is shown in Figure 8.

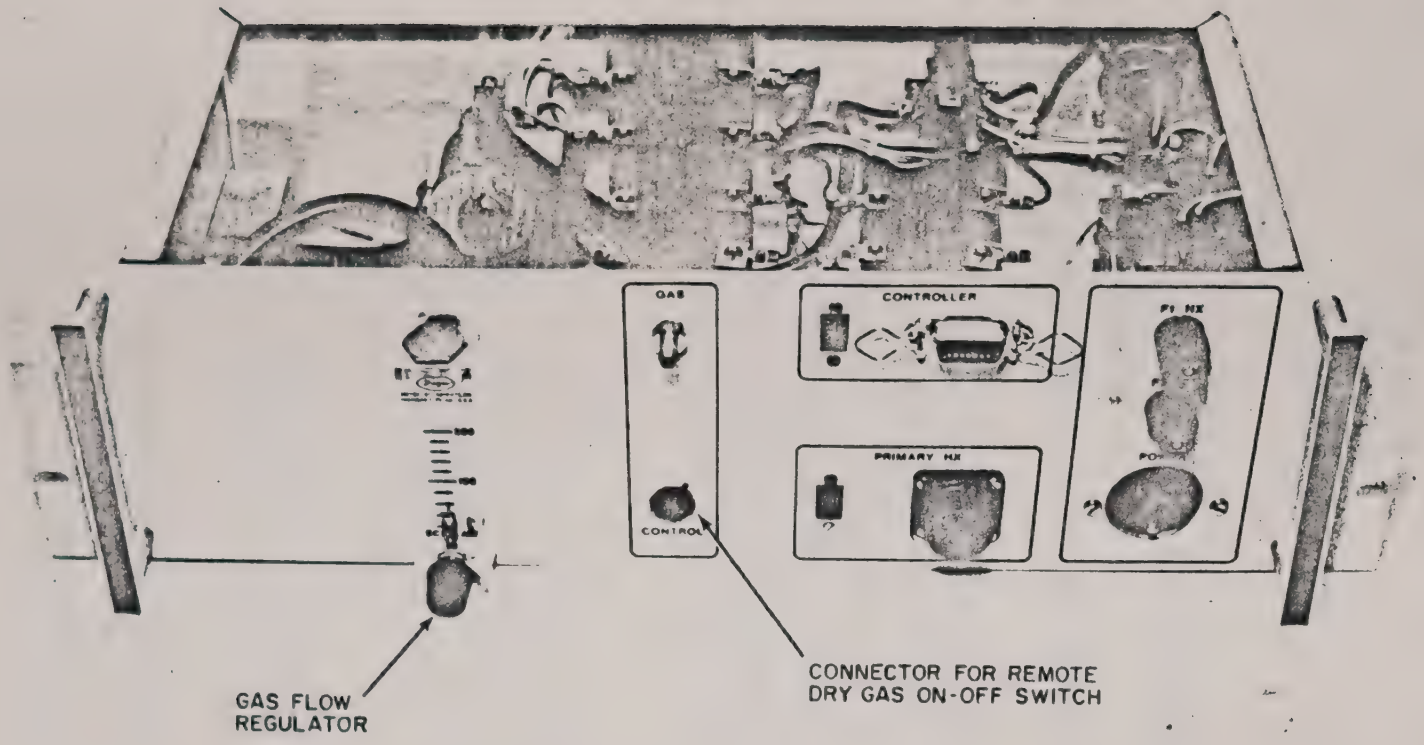


Figure 8. Power control unit panel.

3.2 OPERATING INSTRUCTIONS

3.2.1 System Start-Up and Operation

1. Check that all interconnections have been made as shown in Figure 5.
2. Dial the selected set temperatures on the three TEMPERATURE SET selector switches (index numbers 6, 7, and 8 in Figure 6).
3. See that the primary heat exchanger is conveniently placed.
4. Verify that all necessary supplementary instruments and connectors are on hand and placed conveniently.
5. Depress POWER switch to turn system on. The system will be ready for operation after a thirty-minute warm-up period, but a one-hour warm-up period is recommended to assure stabilization of the digital thermometer.

NOTE

When components are being tested at temperatures of about +25°C, the temperature should be set on the top TEMPERATURE SET selector switch, since CONTROL SELECT "1" is automatically selected when power is applied.

6. Locate the primary heat exchanger thermocap over the tester, insert the component to be tested, and lower the primary heat exchanger over the component.
7. Turn on the flow of dry gas into the primary heat exchanger by means of the gas flow on-off switch on the thermocap of the primary heat exchanger (see Figure 7) or by using a remote user-installed switch.

8. Observe the digital temperature readout as it approaches the set temperature. When the temperature of the gas stream is within $\pm 2^{o}C$ of the set temperature, the AT TEMP indicator will illuminate.

9. Temperature of the component to be tested will attain a stable test temperature shortly after the AT TEMP indicator illuminates. The time required for a component to reach the required test temperature will vary depending on the component size and shape, the socket size and shape, and other physical factors. The time required must be determined by testing for each type of component.

10. Test the component when it attains the test temperature.

3.2.2 System Shut-Down

To turn the Model TP450A ThermoStream System off, depress the POWER switch on the front panel of the digital controller and turn off the gas supply to the primary heat exchanger by turning off the switch on the thermocap of the primary heat exchanger.

3.3 SYSTEM CHECKOUT

The Model TP450A ThermoStream System has been calibrated and checked during an extensive burn-in and test period prior to shipment, and therefore no further calibration of the equipment is necessary. Prior to operation, it is suggested that the operator perform the following system check-out procedures, both to familiarize himself with the equipment and to ensure that the system interconnections have been made properly.

Attach the two power cables to the selected power sources and to the digital controller and the thermal generator. With the pushbuttons, set the top TEMPERATURE SET indicators to read +025. Next, set the center TEMPERATURE SET indicators to read -060. Finally, set the lower indicators to read +150.

The Model TP450A ThermoStream System is now set up to read and to compare gas stream temperature versus set temperatures at a nominal value and at the system extremes. The system check will cover the full range of indicators and controls. To perform a complete system check-out, follow the procedures of Table 3.

Table 3. System check-out procedures.

Step No.	Action	Observation	Explanation
1	Depress POWER indicator switch	POWER indicator is illuminated. CONTROL SELECT "1" is illuminated. The top TEMPERATURE SET light is on. The TEMPERATURE ^{o}C display is stable.	When power is applied, the internal logic generates a pulse (initialize) which automatically causes selection of Channel 1 as the set temperature at which the gas stream temperature will be compared and controlled. The first stage of the refrigeration system will be activated.
2	Wait ≈10 minutes	Within 10 minutes, a click should be heard as the second stage of the secondary heat exchanger is activated. The externally mounted cooling fans are also activated.	The set temperature/gas stream temperature comparison and control at low temperature will proceed only after the second stage of the cascade refrigeration system and the gas stream have been activated. The refrigeration system noise indicates second-stage start-up.
3	Wait ≈30 minutes	The refrigeration second stage is operating to reach temperature stability.	System requires a 30-minute cool-down period to attain the specified low temperature limit.
4	Turn on the dry gas flow and watch the temperature display	The TEMPERATURE ^{o}C display will continue to cycle down until the gas stream temperature has reached the set temperature. When the display is within 2^{o} of the set temperature, the AT TEMP indicator will light.	The temperature may cycle to $\pm$2^{o}C of the set temperature. This is normal operation. The component under test, however, due to its mass (greater than the thermocouple sensor in the gas stream), will be controlled at within $\pm$0.5^{o}C of a stabilization temperature.

Table 3. System check-out procedures. (Continued)

Step No.	Action	Observation	Explanation
5	Depress CONTROL SELECT "2"	CONTROL SELECT "1" extinguishes. CONTROL SELECT "2" illuminates. Top TEMPERATURE SET indicator extinguishes. Center TEMPERATURE SET light illuminates. AT TEMP extinguishes. TEMPERATURE ^{o}C cycles down.	The logic has determined that the gas stream temperature is now to be compared and controlled at the lower limit as set on Channel 2. Comparison is made between the temperature set on the center TEMPERATURE SET indicator and the gas stream temperature and the system cycles down until the lower temperature limit is reached.
6	Observe the display	When the TEMPERATURE ^{o}C display shows -058, the AT TEMP indicator should light. The display should go to -060$\pm$1^{o}C and hold steady.	The change to -060 does not require any additional waiting period. The system merely shifted to Channel 2 and proceeded to control at the low temperature limit.
7	Increment the units push-button on center TEMPERATURE SET indicator to -063	The OUT OF RANGE alarm indicator should light. The AT TEMP display is extinguished momentarily.	The Model TP450A ThermoStream System controls over the range -60^{o}C through +160^{o}C. Any settings beyond these ranges are indicated by the OUT OF RANGE indicator. However, the system will try to achieve any out of range temperature that is requested.
8	Depress CONTROL SELECT "3"	CONTROL SELECT "2" will extinguish. CONTROL SELECT "3" lights. The bottom TEMPERATURE SET indicator will light. AT TEMP will extinguish. TEMPERATURE ^{o}C will start cycling upward.	The logic determines that the gas stream temperature is to be compared and controlled at the higher temperature limit as set on Channel 3. The system will continue heating until the set temperature (+150) keyed in on the lower TEMPERATURE SET indicator has been reached.

Table 3. System check-out procedures. (Continued)

Step No.	Action	Observation	Explanation
9	Observe the display	The TEMPERATURE ^{o}C reading will continue to cycle upward. When the gas stream temperature and the display reach +148, the AT TEMP indicator will light. The temperature should reach +150$\pm$2^{o}C and hold steady.	The system is now controlling the gas stream temperature at the upper system temperature.
10	Increment the TEMPERATURE SET push-buttons to read +161 on the lower indicator	The OUT OF RANGE indicator will light. The AT TEMP light will extinguish. The TEMPERATURE ^{o}C display will cycle up to the new temperature and the AT TEMP and OVERHEAT indicators will be lighted (at +159 and +161, respectively). When the OVERHEAT indicator comes on, the TEMPERATURE ^{o}C display will start to cycle down and the AT TEMP indicator will extinguish.	The logic has determined that the new set temperature is beyond the system limits and that the gas stream temperature has gone beyond range. The logic then turns off the power to the heater and locks it out.
11	Depress CONTROL SELECT "1"	The CONTROL SELECT "3" indicator will extinguish. CONTROL SELECT "1" will light. The TEMPERATURE ^{o}C display will be stable. The OVERHEAT indicator stays lighted.	Although the logic has determined that a new channel has been selected, it cannot proceed with the new comparison and control until there is operator intervention to restore power.

Table 3. System check-out procedures. (Continued)

Step No.	Action	Observation	Explanation
12	Depress the OVERHEAT indicator/ switch	The OVERHEAT indicator will extinguish. The TEMPERATURE ^{o}C display will cycle down to the Channel 1 set temperature (+025) At +027, the AT TEMP indicator will light.	As soon as the operator restores power, the system continues with the temperature control function on the selected channel. The power lock out at the OVERHEAT condition insures that the primary heat exchanger will not be damaged.
13	Depress power switch and reset all three channels to within limit settings	The display panel will show no active indicators.	The system is turned off and reset for the next use.

SECTION 4

MAINTENANCE AND REPAIR

4.1 GENERAL

For the most part, the Model TP450A ThermoStream System is a trouble-free system. Therefore, there is no routine maintenance or repair suggested. However, as is the case with any equipment, it is possible that there will be instances during the system life time when some minor corrective steps may be required; i. e., replacement of fuses and lamps, recalibration of the system, etc.

Should the system ever evidence drift, where either the digital thermometer indicates a gas stream temperature that is not correct or the system does not control within the set temperature specification, the procedures in Section 4.2 should be followed. Other possible malfunctions and recommended corrective actions are listed in Table 4.

4.2 TEMPERATURE CALIBRATIONS

4.2.1 Digital Thermometer Calibration

It is possible, in time, that the digital thermometer readout could drift. Should it be shown that the digital thermometer display does not agree with the gas stream temperature within the specified limits (see Section 1.1), recalibration of the digital thermometer is necessary. To recalibrate the digital thermometer, the calibration system illustrated in Figure 9 is required. Setup procedures for this calibration system are given in steps 1 through 7 below. Recalibration is then easily accomplished by following the procedures given in steps 8 through 18.

Table 4. Possible faults and likely corrections.

Fault	Possible Cause	Correction
POWER indicator lamp fails to light when switch is depressed.	1. Cable not connected. 2. Fuse (1 amp) in digital controller missing or blown. 3. Lamp burned	1. Check and connect. 2. Check and replace 3. Check and replace.
Any indicator fails to light when switch is activated.	Lamp faulty or burned.	Pull out lens/lamp assembly (one piece) and replace lamp.
Cool down takes overly long.	Coolant low.	Consult factory service.
System does not control at set temperature.	System is out of calibration.	Perform system calibration procedures given in Section 4.2.3.
Digital thermometer displays incorrect dry gas stream temperature.	Digital thermometer is out of calibration.	Perform digital thermometer calibration procedures given in Section 4.2.1.
Digital thermometer displays extraordinarily low temperature.	Open thermocouple.	Consult factory service.
False overheat indication.	Noise on digital controller AC supply.	Plug unit into a different outlet.
No dry gas flow.	Wet gas has condensed or frozen and is blocking gas stream passageway.	Shut system down and wait until gas unfreezes (several hours, if necessary).
No heating.	Excessive or insufficient gas supply rate.	Adjust dry gas flow and incoming pressure according to system specifications.

Setup of Calibration System

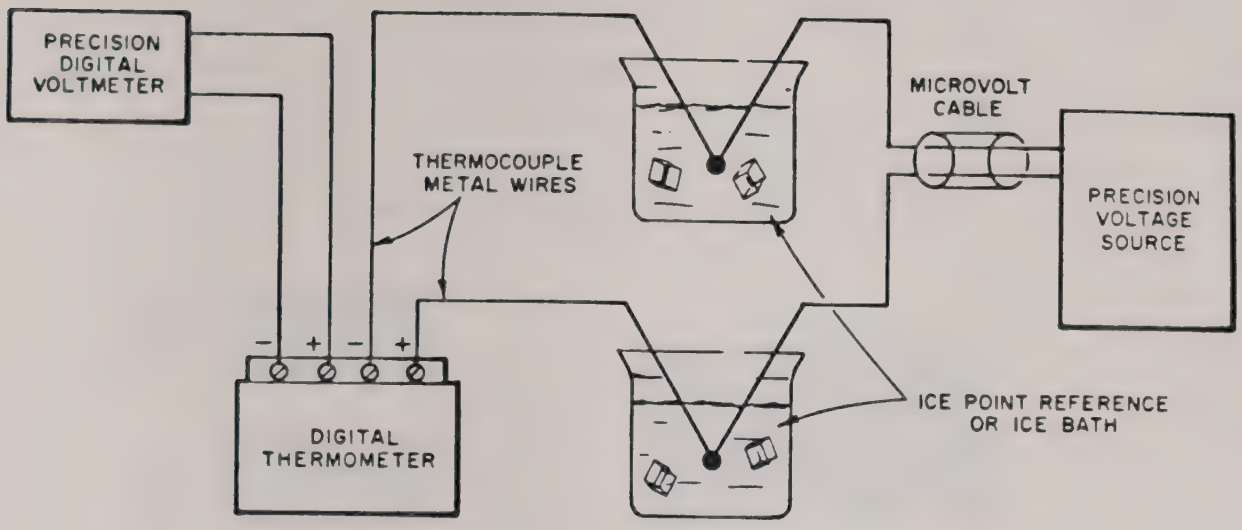


Figure 9. Setup for calibration of digital thermometer.

1. Turn power off.
2. Select the thermocouple wire corresponding to the metals of the designated thermocouple, and prepare a test cable of not more than three feet in length.
3. Connect one end of the test cable to the digital thermometer, being careful to connect the "red" lead to the negative terminal of the digital thermometer.
4. Braze the other ends of the test cable to copper leads, forming two thermocouple junctions. Cover each junction with a piece of heat-shrink tubing or other waterproofing material.
5. Connect the copper leads to a test voltage generator.
6. Immerse each test cable thermocouple junction into a bath of water. Maintain the water at a measured 0°C by keeping fresh-water ice cubes in the water bath.

7. Connect the digital thermometer output screw terminals to a precision digital voltmeter, being careful to observe the polarity conventions shown in Figure 9.

Calibration of Digital Thermometer

8. Lift out the front optical filter of the digital thermometer as shown in Figure 10, thereby providing access to the calibration adjustment potentiometers shown in Figure 11.

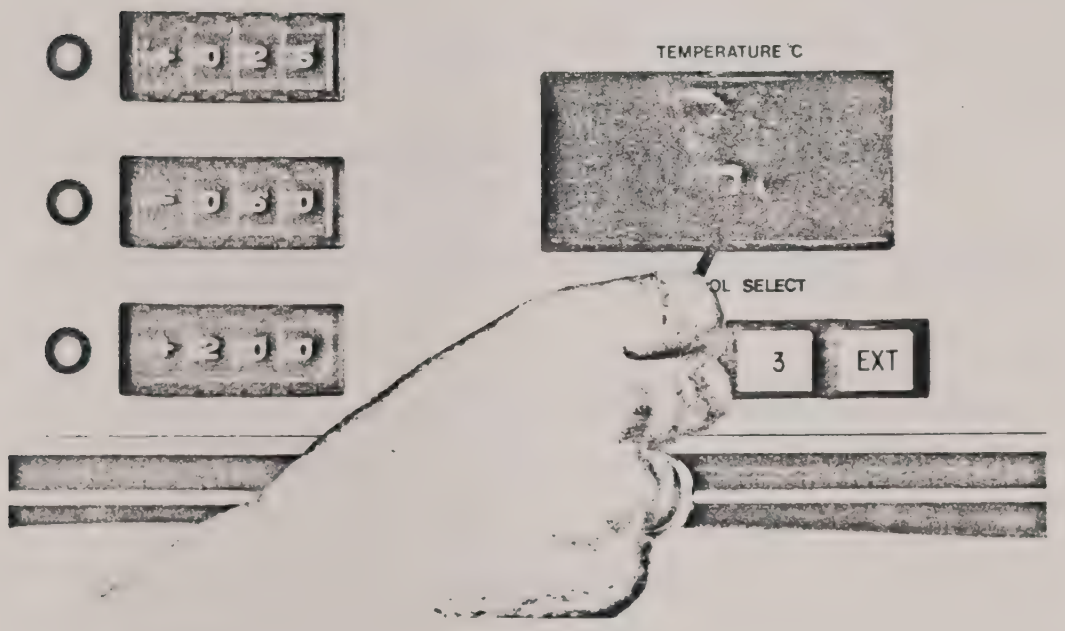


Figure 10. Removal of digital thermometer front face panel.

9. Turn power ON.

10. Set voltage standard output to -2892 microvolts.

11. Adjust R39 (see Figure 11) to display -060. For the analog output, adjust R42 to obtain -60.0 millivolts.

12. Set voltage standard output to 8008 microvolts.

13. Adjust R9 (see Figure 11) to display +150. For the analog output, adjust R48 to obtain 150.0 millivolts.

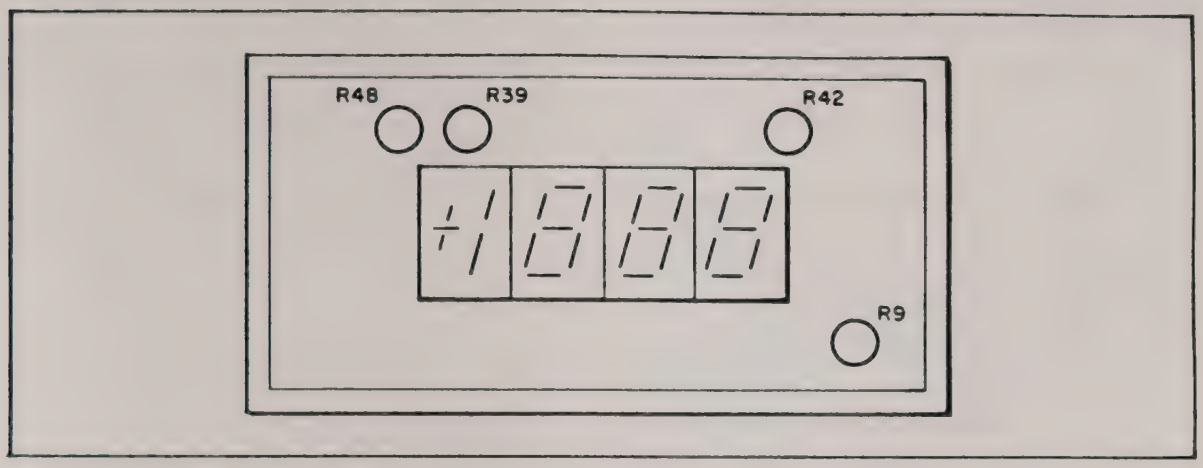


Figure 11. Potentiometer adjustments in calibration of digital thermometer.

14. Repeat steps 10 through 13 until no further adjustment is necessary.

15. Turn power off.

16. Disconnect test cable and analog output test cable.

17. Snap flexible optical DPI filter back in place.

18. Connect system for use.

4.2.2 Digital Thermometer Specifications

Thermocouple	Type J
Input Impedance	100M ohms nominal (referenced to analog ground)
External (Lead) Resistance Effect	20 microvolts per 350 ohms of lead resistance
Cold-Junction Compensation	Automatic; ±0.03°C/°C from +10°C to +40°C; ±0.05°C/°C from 0°C to +50°C ambient
Thermocouple Short to AC Lines	No effect; automatically protected by built-in circuits to 300V peak, 220V RMS
Maximum Common Mode Voltage Between Input and Power-Line Ground	1400 volts DC or AC peak

Common Mode Rejection Ratio	More than 130 dB, AC power to signal low with 250 ohms unbalance
Normal Mode Rejection Ratio	More than 100 dB at 50/60 Hz
Readout Accuracy	±1/2 digit at 25°C
Temperature Resolution	1°C or 1°F
Range Tempco	50 ppm/°C typical; 80 ppm/°C maximum
Power	110 VAC RMS ±20%, 47 to 500 Hz at 1.6 watts nominal (88 to 132 VAC input range); 220 VAC RMS ±20%, 47 to 500 Hz at 1.6 watts nominal (176 to 264 VAC input range)
Type	Seven-segment planar LED, red, 0.43 inch (11 mm) high
Polarity Indication	Automatic "+" or "-" sign displayed
Overrange Indication	All digits blanked to prevent erroneous readout, "+" or "-" sign remains on
Operating Temperature Range	-10°C to +50°C
Case	DIN/NEMA standard, high impact molded plastic case; metal case available (see Chapter 3 for size and mounting)
Weight	8 ounces (226 grams) nominal, DC powered; 11 ounces (312 grams) nominal, AC powered

4.2.3 System Calibration

It is possible that after extended use the system will no longer control at the set temperature (±1°C or ±1% of setting, necessitating readjustment of the three system calibration potentiometers (R01, R02, and R03). The recalibration procedure is as follows:

1. Allow a 2-hour warm-up time. If the calibration procedure in Section 4.2.1 has been performed, merely allow time for the second stage of the refrigeration system to start. Remove the four front panel screws to allow the digital controller to slide part way out of the cabinet.

2. Set the temperature set switches as follows:

Top	+000
Center	+150
Bottom	-050

3. Depress CONTROL SELECT "1" and observe if the system controls at +000.

4. If adjustment is necessary, slide the digital controller out from the cabinet, being careful not to disconnect cables and power cord, and adjust R03 (see Figure 12) until the display reads +000.

WARNING

Potentially lethal voltages are present in the exposed digital controller. Use extreme caution.

5. Return the digital controller to the cabinet and depress CONTROL SELECT "2."

6. Observe if the system goes to and controls at +150±2°C.

7. If adjustment is necessary, slide the digital controller out from the cabinet and adjust R02 (see Figure 12) until the system controls at +150±2°C.

8. Return the digital controller to the cabinet and depress CONTROL SELECT "3."

9. Observe if the system goes to and controls at -050±1°C.

10. If adjustment is necessary, slide the digital controller out and adjust R01 (see Figure 12) until the system controls at -050±1°C.

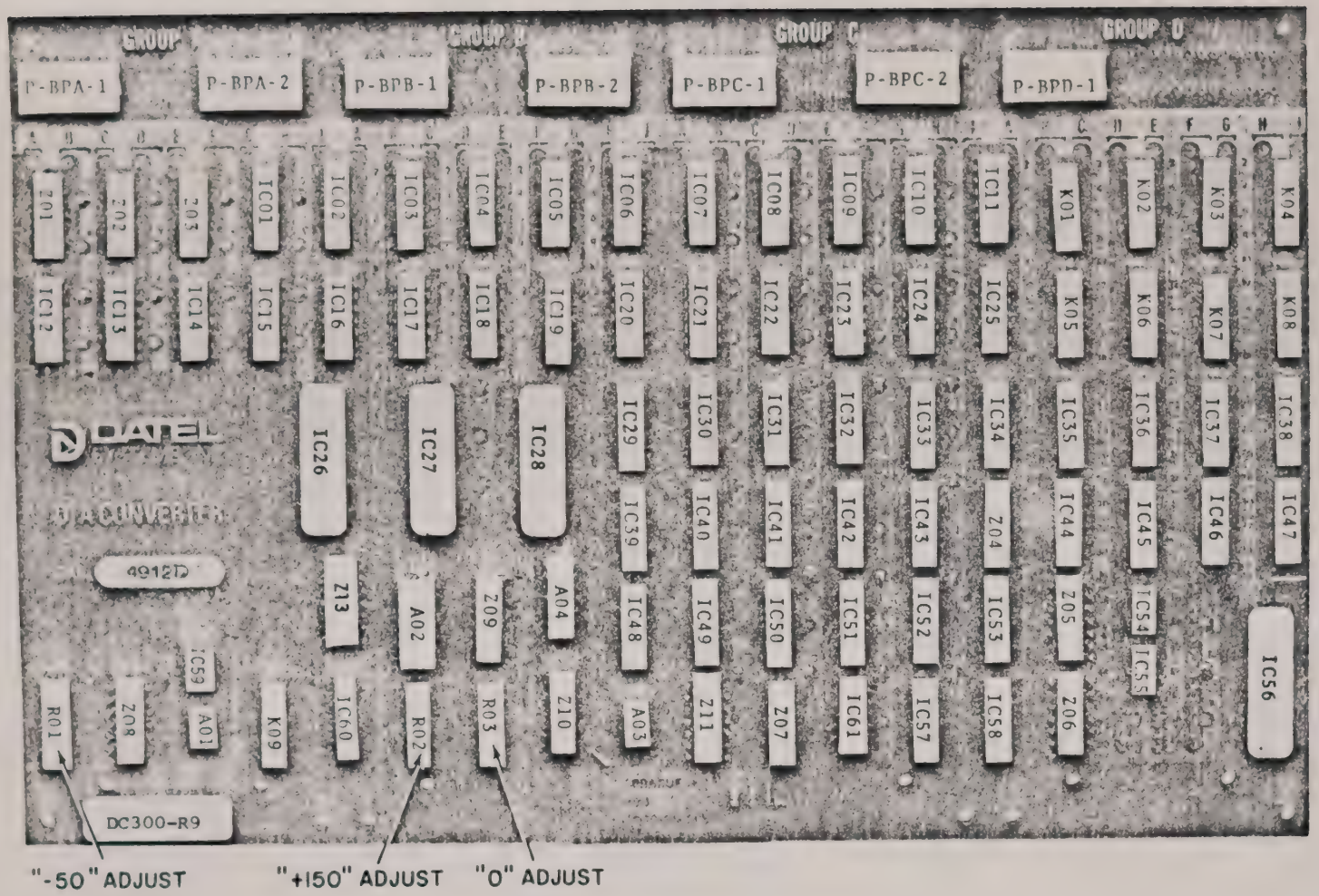


Figure 12. Potentiometer adjustments in calibration of temperature setting dials.

11. Return the digital controller to the cabinet, replace the four screws, set +025 on the top pushbutton selector switch, and depress CONTROL SELECT "1."

This completes the System calibration.

NOTE

It is possible to calibrate the system and digital thermometer for exact control and read-out of a specific temperature; however, this may cause greater than specified errors at other temperatures.

4.3 ELECTRICAL CHECKS, POINT-TO-POINT

It is conceded that one or another of the internal electronic components could degrade or fail and cause system disfunction during life. However, to preclude the possibility that untrained personnel might try to perform circuit board repairs for which they are not trained, no detailed circuit board troubleshooting is provided in this manual.

In the event that a system failure occurs that cannot be cured by a simple lamp, fuse, or coolant replacement, contact TEMPTRONIC by phone or Telex.

For the benefit of those users who are qualified to perform in-depth circuit board analyses and component replacement, a complete set of schematic, logic, and wiring diagrams has been included in Appendix A of this manual. It is suggested that the user call and describe the type of malfunction evidenced. The TEMPTRONIC engineering personnel or field service representatives can then suggest particular circuit board areas that should be tested and the specific measurement and pin areas that will pinpoint the problem.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

The Model TP450A ThermoStream System is comprised of three functional elements: a heater, cooler, and a logic unit. The entire system operation is controlled by the logic unit in the digital controller.

5.2 LOGIC (see Figure 13)

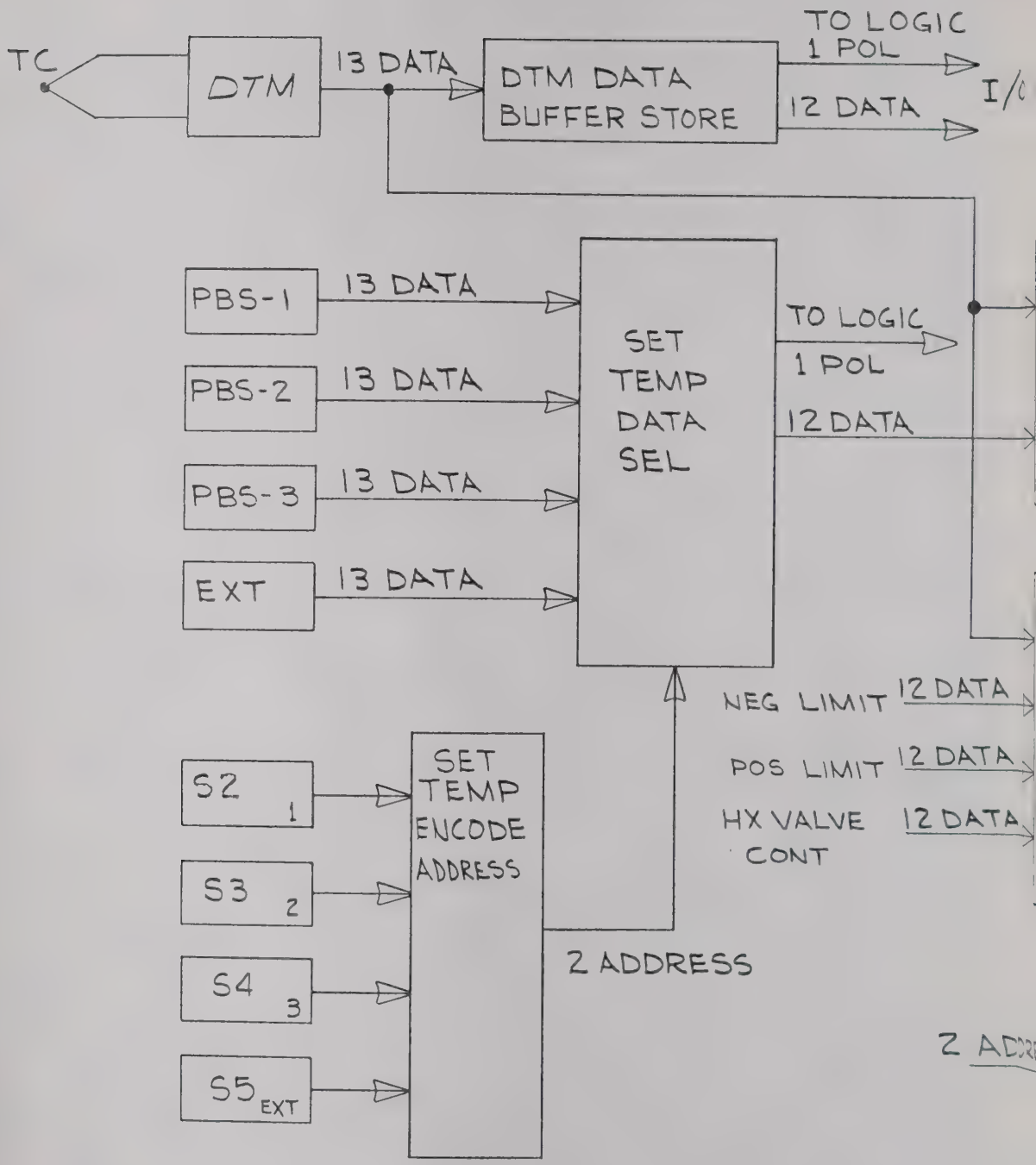
5.2.1 Clock

Upon system turn-on, a single pulse (initialize) is generated which sets all flip-flops. The initialize pulse also generates a 3-second delay pulse for all alarms. The basic logic control element is a clock which operates at ≈160 pps.

The clock pulses drive a 4-bit binary counter. The 2^2 bit from the binary counter controls the set temperature data selection (word "A"). The 2^0 and 2^1 bits control the word select "B" data selector. The four bits from the binary counter are inputted to a 4-line to 16-line multiplexer. The first eight lines are used to update the contents of different storage registers (see Table 5).

Table 5. Clock pulse vs function.

Clock	Function
1	Not used
2	Overheat
3	Update DTM
4	Not used


TC
DTM
13 DATA
DTM DATA BUFFER STORE
TO LOGIC
1 POL
12 DATA
I/O
PBS-1
13 DATA
PBS-2
13 DATA
PBS-3
13 DATA
EXT
13 DATA
SET TEMP DATA SEL
TO LOGIC
1 POL
12 DATA
NEG LIMIT
12 DATA
POS LIMIT
12 DATA
HX VALVE CONT
12 DATA
S2 1
S3 2
S4 3
S5 EXT
SET TEMP ENCODE ADDRESS
2 ADDRESS

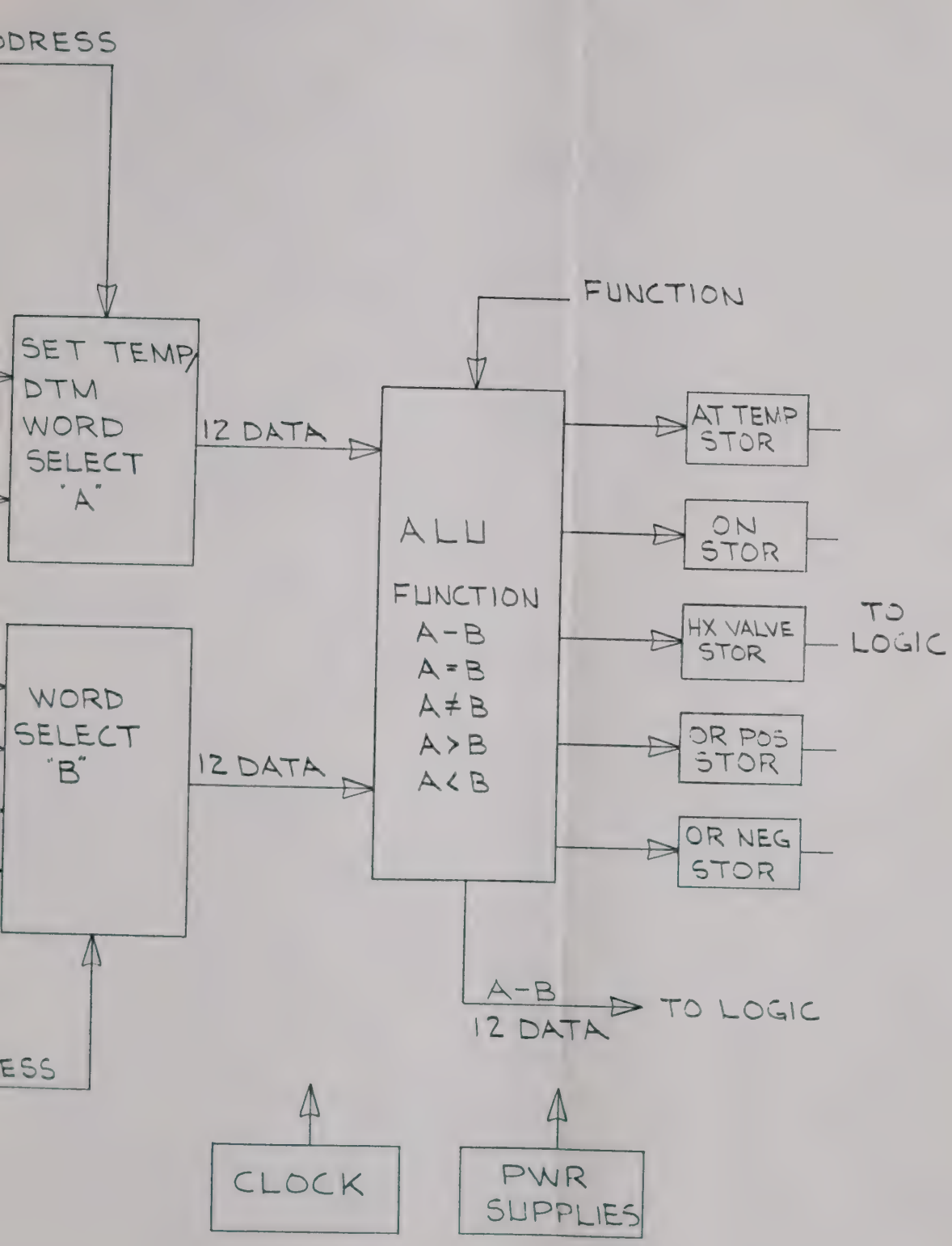


Figure 13. Logic block diagram.

Table 5. Clock pulse vs function. (Continued)

Clock	Function
5	(-) Out of range
6	(+) Out of range
7	Not used
8	At temp
9	Reset

5.2.2 Set Temperature Data Selector

The set temperature data selector is addressed by the set temperature encoder. Front panel switches (CONTROL SELECT) generate a 4-bit decimal word in the set temperature encoder which is converted to a 2-bit binary address. The set point data from one of the three front panel pushbutton switches on the external input is inputted to the word select "A" selector.

Word select "A" inputs the digital temperature meter data to the arithmetic logic unit (ALU) for four clock counts and then inputs the set temperature data for four clock counts.

Word select "B" inputs the digital temperature meter data, the negative limit, the positive limit, and the valve control data to the ALU. The four-word cycle is repeated twice in each eight-count clock cycle.

The ALU performs different functions during the clock cycle to generate control and alarm signals. Additional logic is used with the AT TEMP signal from the ALU to provide the AT TEMP window.

5.2.3 Heater Control

A two-stage differential amplifier senses the difference between the set temperature and the gas stream temperature. The amplifier output drives a comparator which controls the heater relay in the power control unit.

5.2.4 Power Control Unit

Inputs from the digital controller operate relays which control power to the refrigeration system, operate the dry gas solenoid valve, and control the AC heater supply.

5.2.5 Logic Interface

The 36-pin connector that interfaces the logic with the system elements is at the rear of the digital controller. The signals transmitted through the particular pin connections are given in Table 6.

Table 6. Interface connector pin assignments.

(All Signals TTL "1" = TRUE)

Pin Number	Signal	Function
1	Temperature Out	1 (LSB)
2	Temperature Out	2
3	Temperature Out	4
4	Temperature Out	8
5	Temperature Out	10
6	Temperature Out	20
7	Temperature Out	40
8	Temperature Out	80
9	Temperature Out	100
10	Temperature Out	200
11	Temperature Out	400
12	Temperature Out	800 (MSB)
13	NC	
14	Temperature Out Polarity	"1" = (+)
15	Data Ready (Temperature Out) ≈250-ms pulse 50% duty cycle	
16	At Temperature	
17	NC	
18	Logic GND	
19	External Temperature Set	1 (LSB)
20	External Temperature Set	2
21	External Temperature Set	4
22	External Temperature Set	8
23	External Temperature Set	10
24	External Temperature Set	20
25	External Temperature Set	40
26	External Temperature Set	80

Table 6. Interface connector pin assignments. (Continued)

Pin Number	Signal	Function
27	External Temperature Set	100
28	External Temperature Set	200
29	External Temperature Set	400
30	External Temperature Set	800 (MSB)
31	External Temperature Set Polarity	"1" = (+)
32	Overheat	
33	Data Ready (Strobe) (External Temperature Set) 10-μs pulse required	
34	Out of Range (Temperature Set)	
35	NC	
36	External Enable Jumper between pins 18 and 36 or logical ground at pin 36 enables EXTERNAL CONTROL SELECT switch.	

NOTE

Pins 1-17, 32, and 34 are output signals,

Pins 19-31 and 33 are input signals.

APPENDIX A

SCHEMATIC AND WIRING DIAGRAMS AND EQUIPMENT PHOTOGRAPHS

The diagrams and photographs contained in this Appendix include the following:

Diagrams

Digital temperature control schematic (Dwg. No. D-2173 - 11 sheets)

Power control schematic (Dwg. No. B-2062)

Cascade heat exchanger wiring diagram (Dwg. No. C-2586)

Cascade heat exchanger piping schematic (Dwg. No. B-2585)

Photographs

Back plane 1 with schematic references

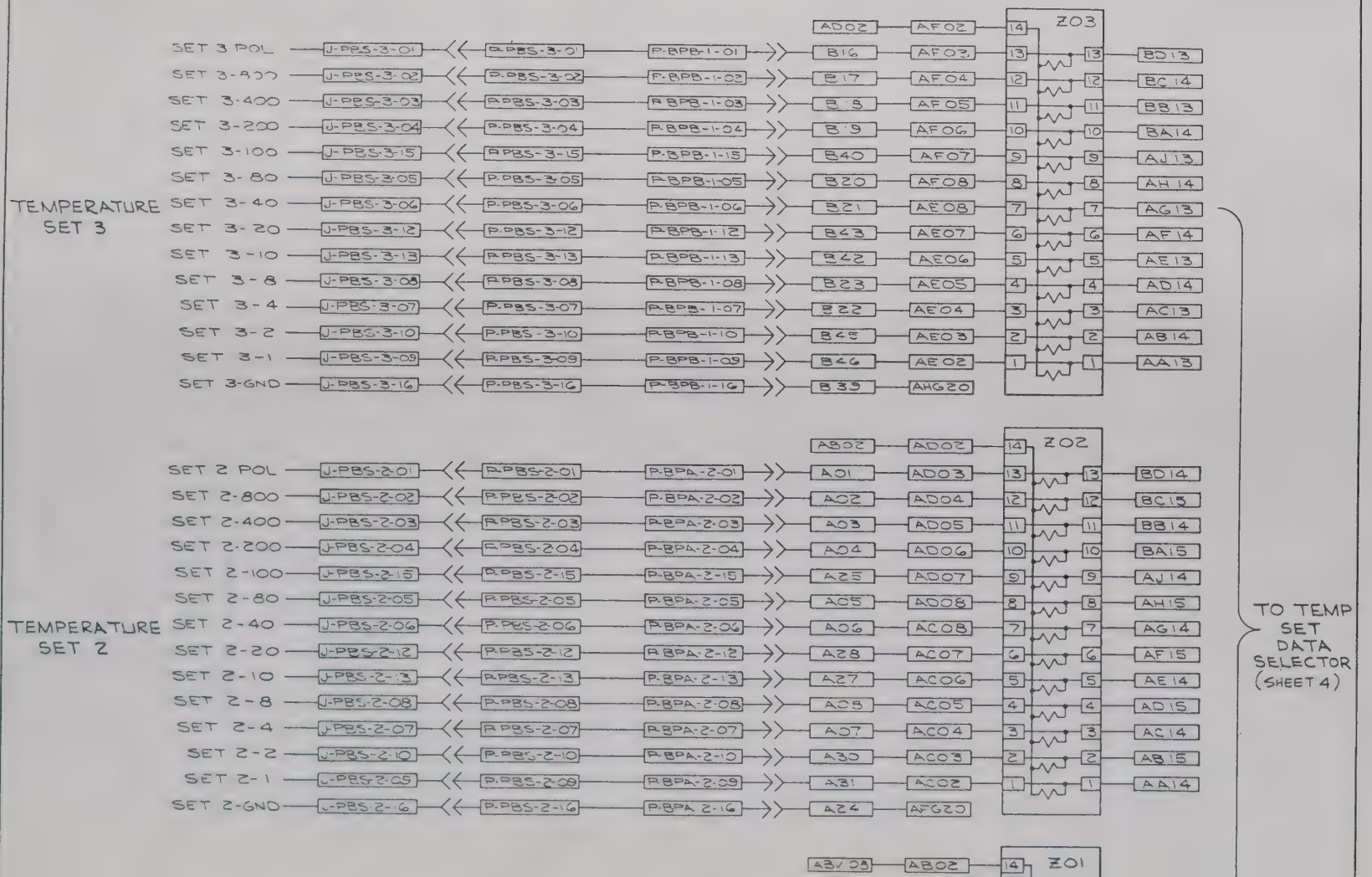
Back plane 2 with device types

Interior of digital controller

Interior of power control

Secondary heat exchanger, front view

Secondary heat exchanger, rear view


TEMPERATURE SET 3
SET 3 POL
SET 3-800
SET 3-400
SET 3-200
SET 3-100
SET 3-80
SET 3-40
SET 3-20
SET 3-10
SET 3-8
SET 3-4
SET 3-2
SET 3-1
SET 3-GND
J-PBS-3-01
J-PBS-3-02
J-PBS-3-03
J-PBS-3-04
J-PBS-3-15
J-PBS-3-05
J-PBS-3-06
J-PBS-3-12
J-PBS-3-13
J-PBS-3-08
J-PBS-3-07
J-PBS-3-10
J-PBS-3-09
J-PBS-3-16
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P-PBS-3-02
P-PBS-3-03
P-PBS-3-04
P-PBS-3-15
P-PBS-3-05
P-PBS-3-06
P-PBS-3-12
P-PBS-3-13
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P-PBS-3-07
P-PBS-3-10
P-PBS-3-09
P-PBS-3-16
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P-BPB-1-06
P-BPB-1-12
P-BPB-1-13
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B16
B17
B18
B19
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B43
B42
B23
B22
B45
B46
B39
AD02
AF02
AF03
AF04
AF05
AF06
AF07
AF08
AE08
AE07
AE06
AE05
AE04
AE03
AE02
AHG20
Z03
14
13
12
11
10
9
8
7
6
5
4
3
2
1
BD13
BC14
BB13
BA14
AJ13
AH14
AG13
AF14
AE13
AD14
AC13
AB14
AA13
TEMPERATURE SET 2
SET 2 POL
SET 2-800
SET 2-400
SET 2-200
SET 2-100
SET 2-80
SET 2-40
SET 2-20
SET 2-10
SET 2-8
SET 2-4
SET 2-2
SET 2-1
SET 2-GND
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P-BPA-2-13
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P-BPA-2-09
P-BPA-2-16
A01
A02
A03
A04
A25
A05
A06
A28
A27
A08
A07
A30
A31
A24
AB02
AD02
AD03
AD04
AD05
AD06
AD07
AD08
AC08
AC07
AC06
AC05
AC04
AC03
AC02
AFG20
Z02
14
13
12
11
10
9
8
7
6
5
4
3
2
1
BD14
BC15
BB14
BA15
AJ14
AH15
AG14
AF15
AE14
AD15
AC14
AB15
AA14
TO TEMP SET DATA SELECTOR (SHEET 4)
AB02
AB02
Z01

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 656	1-31-70	

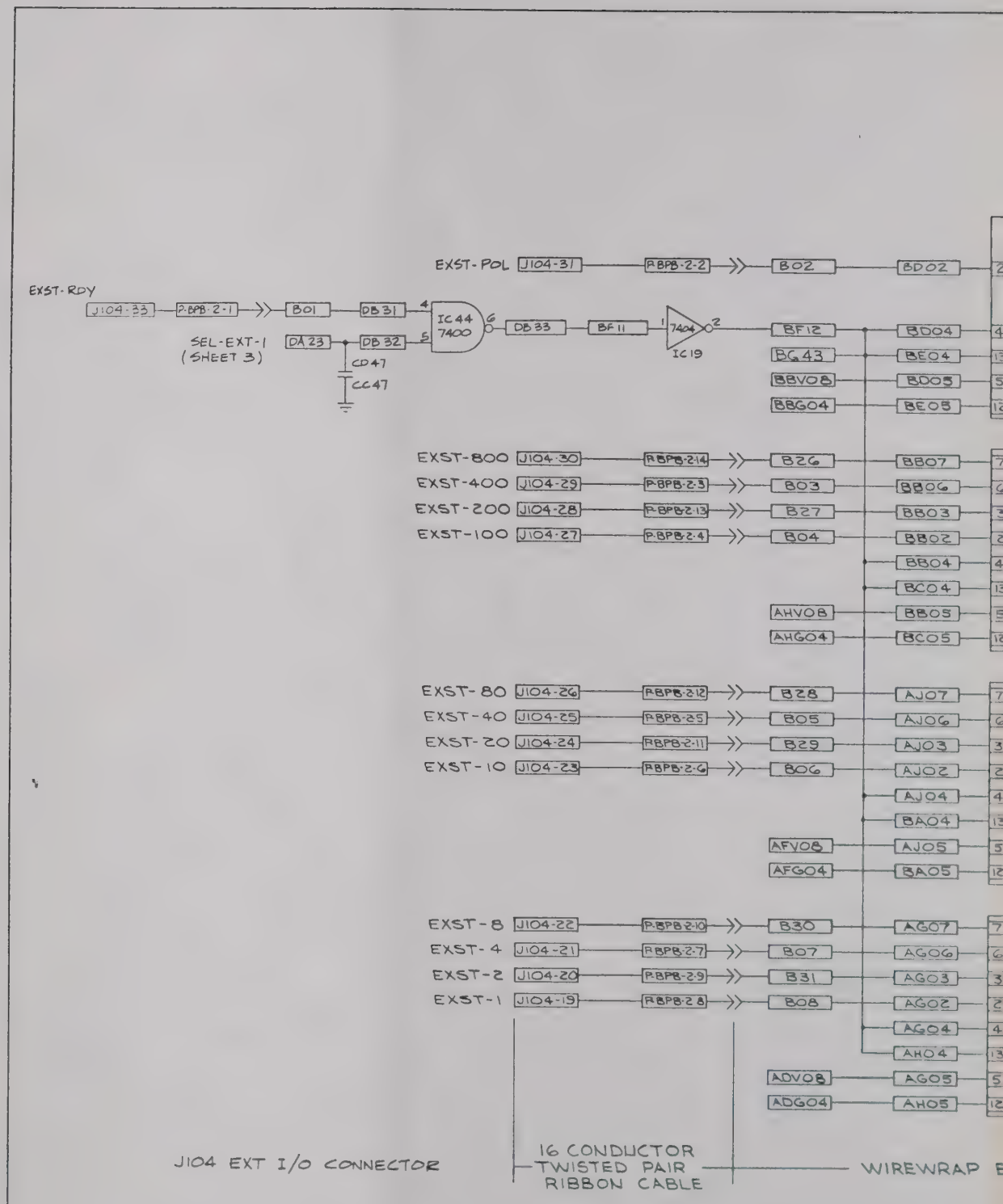
TEMP SET INPUT

TEMPTRONIC

SCHEMATIC
(DIGITAL TEMP. CONTROL)

SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	A

SCALE N.A. SHEET OF


EXST-POL
J104-31
P-BPB-2-2
B02
BD02
EXST-RDY
J104-33
P-BPB-2-1
B01
DB31
IC44
7400
DB33
BF11
7404
IC19
BF12
BD04
SEL-EXT-1
(SHEET 3)
DA23
DB32
CD47
CC47
BG43
BE04
BBV08
BD05
BBG04
BE05
EXST-800
J104-30
P-BPB-2-14
B26
BB07
EXST-400
J104-29
P-BPB-2-3
B03
BB06
EXST-200
J104-28
P-BPB-2-13
B27
BB03
EXST-100
J104-27
P-BPB-2-4
B04
BB02
BB04
BC04
AHV08
BB05
AHG04
BC05
EXST-80
J104-26
P-BPB-2-12
B28
AJ07
EXST-40
J104-25
P-BPB-2-5
B05
AJ06
EXST-20
J104-24
P-BPB-2-11
B29
AJ03
EXST-10
J104-23
P-BPB-2-6
B06
AJ02
AJ04
BA04
AFV08
AJ05
AFG04
BA05
EXST-8
J104-22
P-BPB-2-10
B30
AG07
EXST-4
J104-21
P-BPB-2-7
B07
AG06
EXST-2
J104-20
P-BPB-2-9
B31
AG03
EXST-1
J104-19
P-BPB-2-8
B08
AG02
AG04
AH04
ADV08
AG05
ADG04
AH05
J104 EXT I/O CONNECTOR
16 CONDUCTOR
TWISTED PAIR
RIBBON CABLE
WIREWRAP
EXTERNAL TEMPE
BUFFER/STOR

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 656	1-31-78	

04
75

16 — BE01 — BD12 LEXST-POL

03
75

9 — BC08 — BC13 LEXST-800
10 — BC07 — BB12 LEXST-400
15 — BC02 — BA13 LEXST-200
16 — BC01 — AJ12 LEXST-100

02
75

9 — BA08 — AH13 LEXST-80
10 — BA07 — AG12 LEXST-40
15 — BA02 — AF13 LEXST-20
16 — BA01 — AE12 LEXST-10

01
75

9 — AH08 — AD13 LEXST-8
10 — AH07 — AC12 LEXST-4
15 — AH02 — AB13 LEXST-2
16 — AH01 — AA12 LEXST-1

TO TEMP SET
DATA SELECTOR
(SHEET 4)

KPLANE

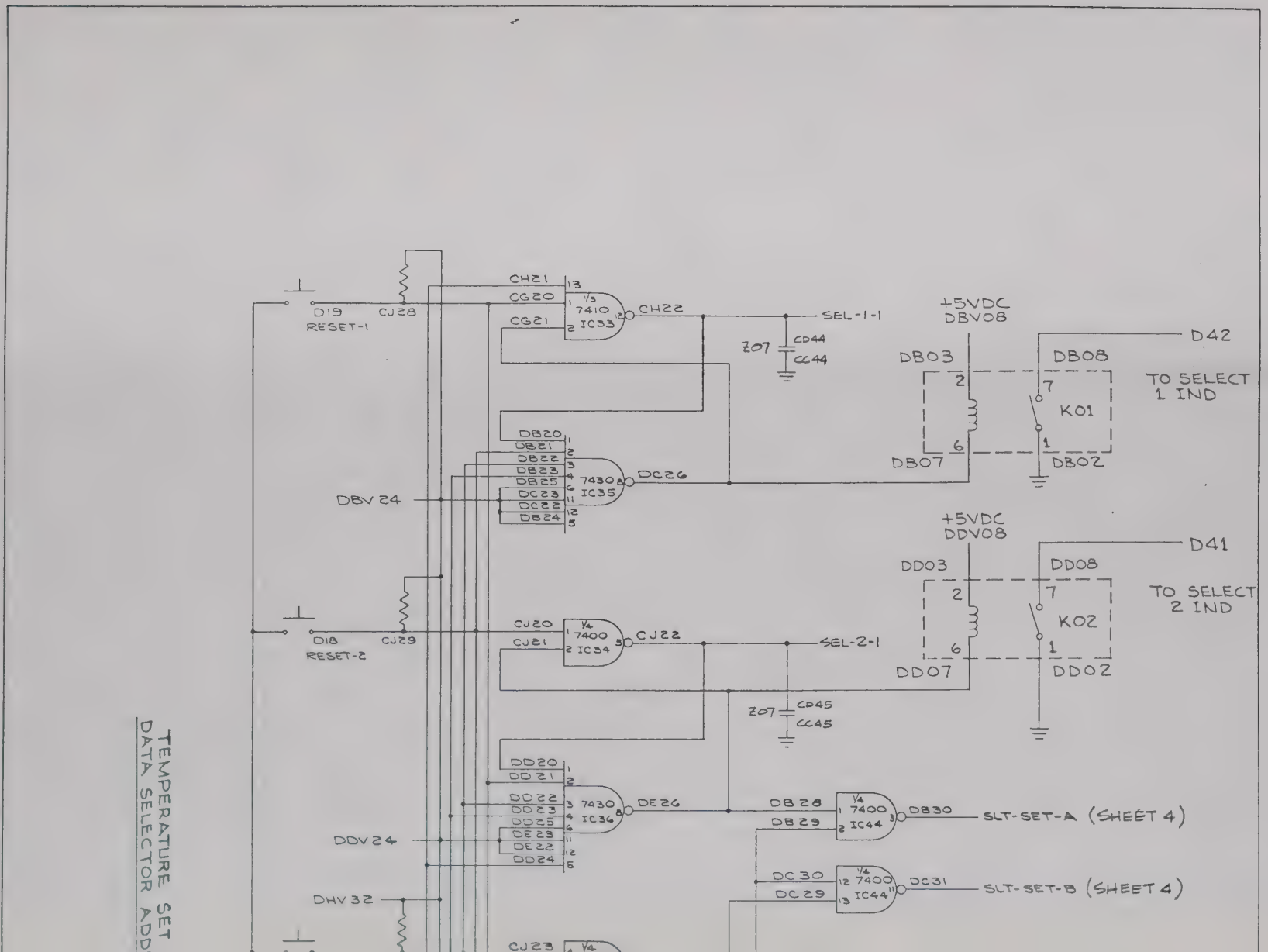
TURE SET
E

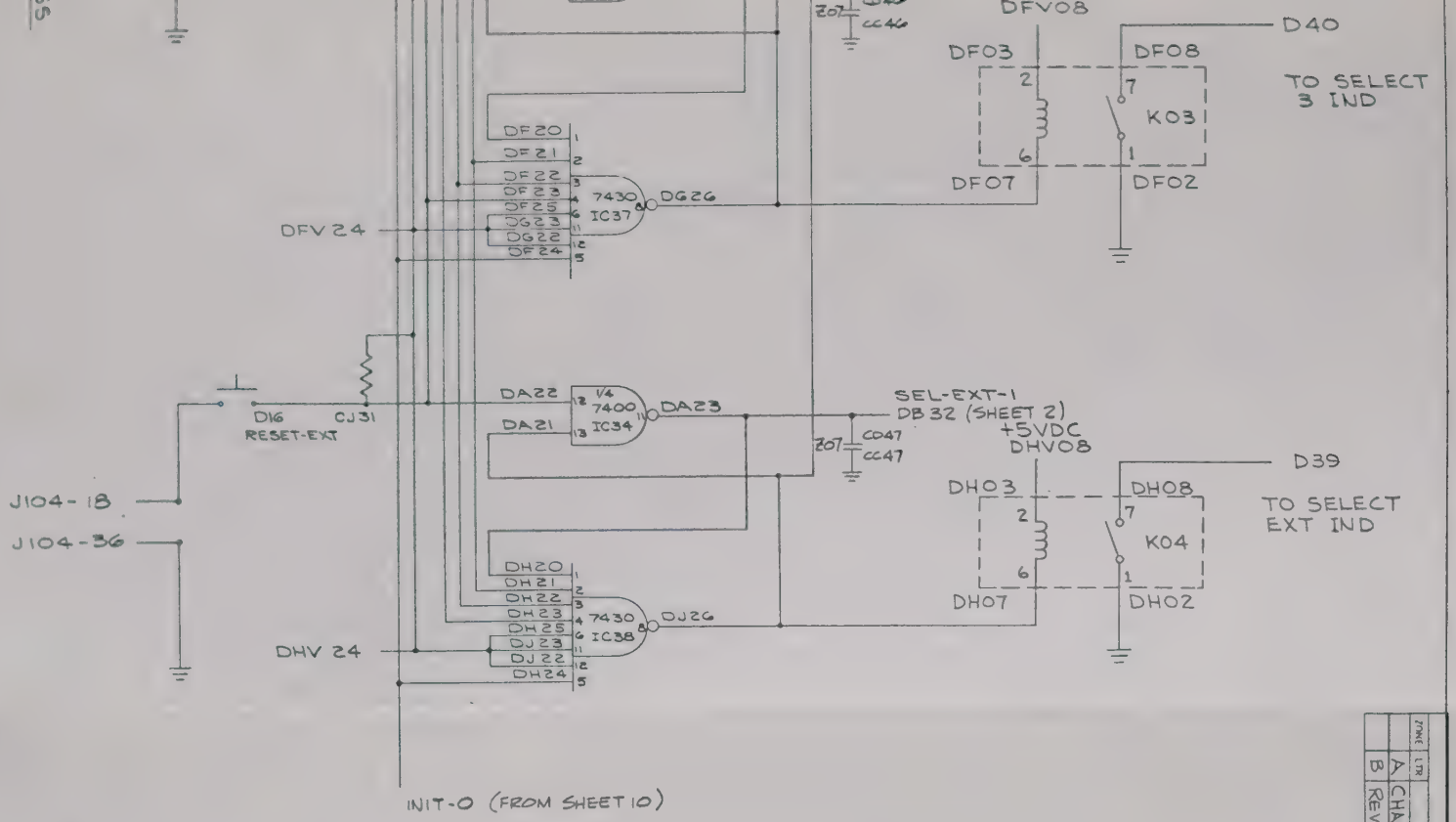
TEMPTRONIC corporation

SCHEMATIC
(DIGITAL TEMP CONTROL)

SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	A

SCALE N.A. SHEET 2 OF 3


TEMPERATURE SET
DATA SELECTOR ADD
D19
RESET-1
CJ28
CH21
CG20
CG21
7410
IC33
CH22
SEL-1-1
Z07
CD44
CC44
+5VDC
DBV08
D42
DB03
DB08
TO SELECT
1 IND
K01
DB07
DB02
DB20
DB21
DB22
DB23
DB25
DC23
DC22
DB24
7430
IC35
DC26
DBV24
D18
RESET-2
CJ29
CJ20
CJ21
7400
IC34
CJ22
SEL-2-1
+5VDC
DDV08
D41
DD03
DD08
TO SELECT
2 IND
K02
DD07
DD02
CD45
CC45
DD20
DD21
DD22
DD23
DD25
DE23
DE22
DD24
7430
IC36
DE26
DDV24
DB28
DB29
7400
IC44
DB30
SLT-SET-A (SHEET 4)
DC30
DC29
DC31
SLT-SET-B (SHEET 4)
DHV32
CJ23



ZONE	LTR	DESCRIPTION	DATE
	A	CHANGED PER DCN #391	7-22-76
	B	REVISED PER DCN 656	1-31-75

REVISIONS

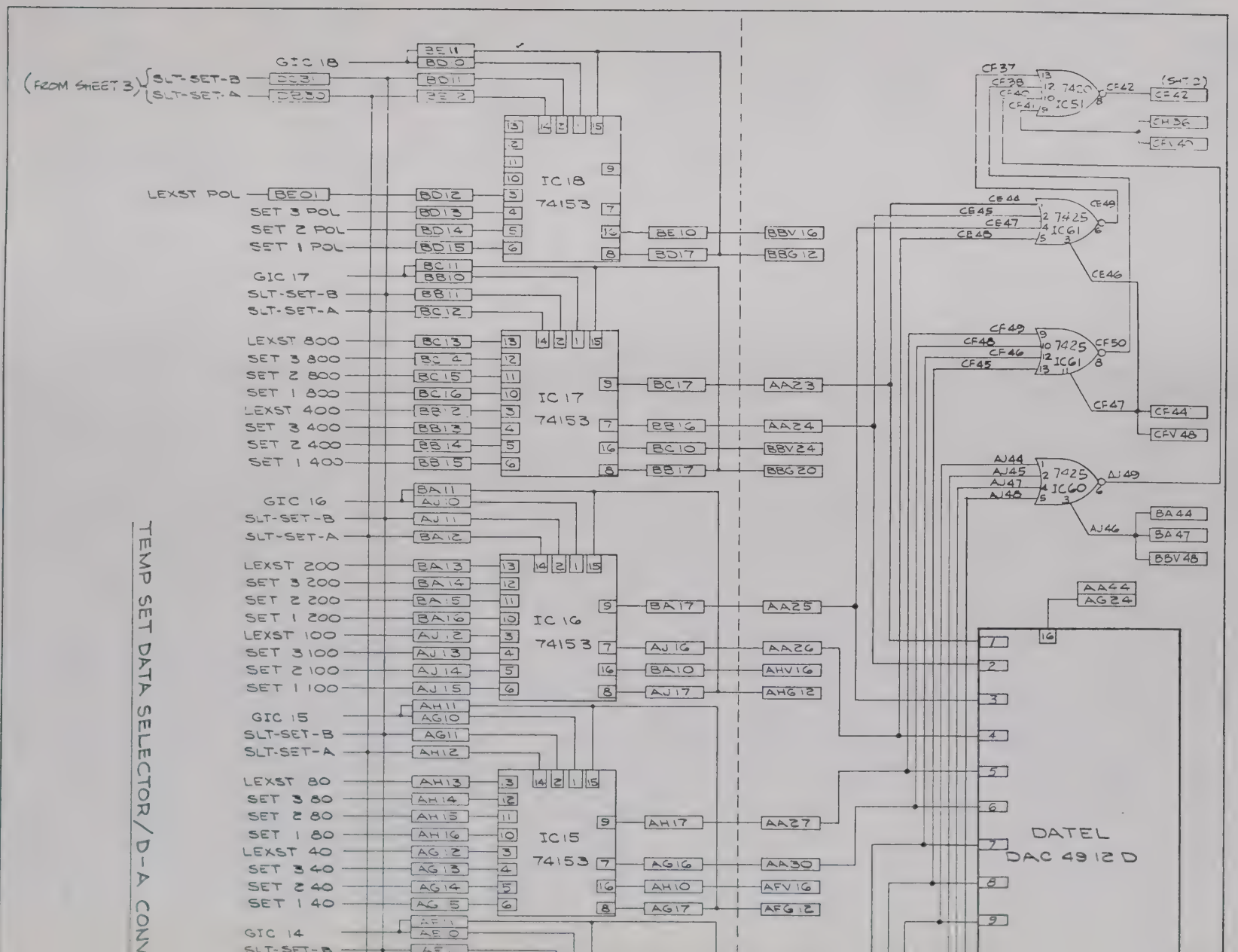
TEMPTRONIC

SCHEMATIC
(DIGITAL TEMP. CONTROL)

SIZE	CODE IDENT NO.	DRAWING NO.	REV
D		2173	B

SCALE NA

SHEET 3 OF 11


TEMP SET DATA SELECTOR/D-A CONN
(FROM SHEET 3)
SLT-SET-B
SLT-SET-A
GIC 18
LEXST POL
SET 3 POL
SET 2 POL
SET 1 POL
IC 18
74153
GIC 17
LEXST 800
SET 3 800
SET 2 800
SET 1 800
LEXST 400
SET 3 400
SET 2 400
SET 1 400
IC 17
GIC 16
LEXST 200
SET 3 200
SET 2 200
SET 1 200
LEXST 100
SET 3 100
SET 2 100
SET 1 100
IC 16
GIC 15
LEXST 80
SET 3 80
SET 2 80
SET 1 80
LEXST 40
SET 3 40
SET 2 40
SET 1 40
IC15
GIC 14
BE10
BD17
BBV16
BBG12
BC17
AA23
BB16
AA24
BBV24
BBG20
BA17
AA25
AJ16
AA26
BA10
AHV16
AHG12
AH17
AA27
AG16
AA30
AH10
AFV16
AFG12
IC51
IC61
IC60
DATEL
DAC 49 12 D
AA44
AG24
BA44
BA47
BBV48
CF44
CFV48
AJ49
AJ46
CF50
CF47
CE49
CE46
CF42
CH36
CF40

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 656	1-31-78	
	B	REVISED PER DCN 730	6-30-78	

T SET SELECTED OUTPUTS
(TO SHEET 7)

SET INPUTS
(FROM SHEET 1)

IC 14 74153
IC 13 74153
IC 12 74153

LEXST 20
SET 3 20
SET 2 20
SET 1 20
LEXST 10
SET 3 10
SET 2 10
SET 1 10
GIC 13
SLT-SET-B
SLT-SET-A
LEXST 8
SET 3 8
SET 2 8
SET 1 8
LEXST 4
SET 3 4
SET 2 4
SET 1 4
GIC 12
SLT-SET-B
SLT-SET-A
LEXST 2
SET 3 2
SET 2 2
SET 1 2
LEXST 1
SET 3 1
SET 2 1
SET 1 1

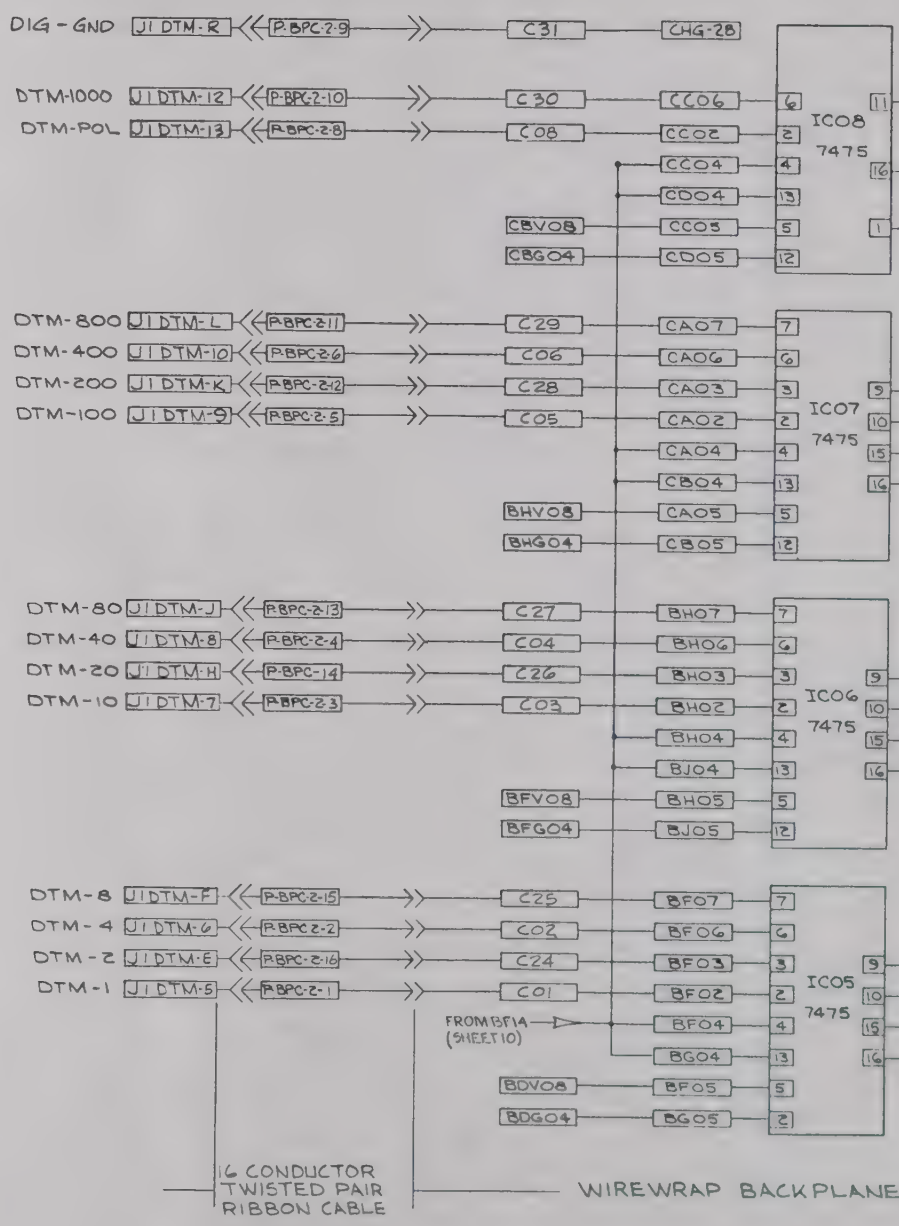
RSION

TEMPTR. VIC

SCHEMATIC
(DIGITAL TEMP. CONTROL)

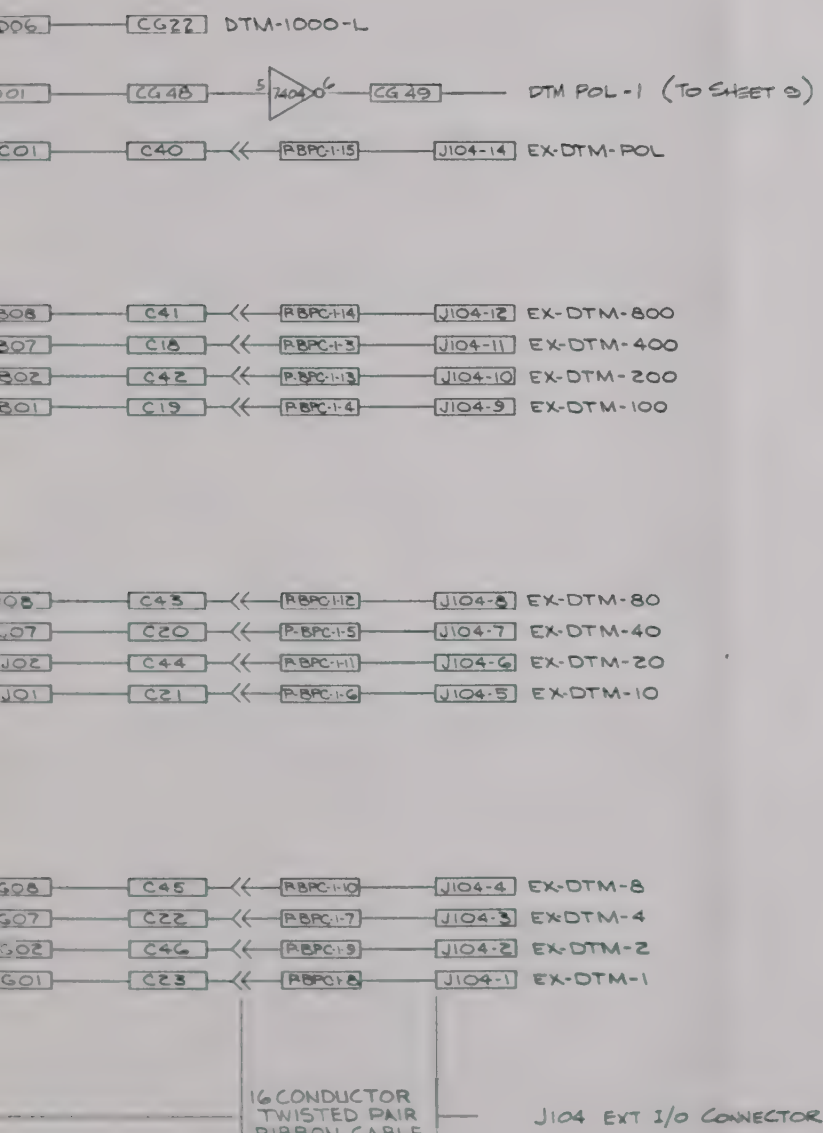
SIZE	CODE IDENT NO	DRAWING NO	REV
D	•	2173	B

SCALE N/A SHEET 4 OF 11



DTM TEMP. DATA BUFFER

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 1656	1-31-75	
	B	REVISED PER DCN 1685	11/23/11	


006 CG22 DTM-1000-L
001 CG48 5 7404 6 CG49 DTM POL-1 (TO SHEET 9)
C01 C40 P-BPC-1-15 J104-14 EX-DTM-POL
808 C41 P-BPC-1-14 J104-12 EX-DTM-800
807 C18 P-BPC-1-3 J104-11 EX-DTM-400
802 C42 P-BPC-1-13 J104-10 EX-DTM-200
801 C19 P-BPC-1-4 J104-9 EX-DTM-100
08 C43 P-BPC-1-12 J104-8 EX-DTM-80
07 C20 P-BPC-1-5 J104-7 EX-DTM-40
02 C44 P-BPC-1-11 J104-6 EX-DTM-20
01 C21 P-BPC-1-6 J104-5 EX-DTM-10
G08 C45 P-BPC-1-10 J104-4 EX-DTM-8
G07 C22 P-BPC-1-7 J104-3 EX-DTM-4
G02 C46 P-BPC-1-9 J104-2 EX-DTM-2
G01 C23 P-BPC-1-8 J104-1 EX-DTM-1
16 CONDUCTOR TWISTED PAIR RIBBON CABLE
J104 EXT I/O CONNECTOR

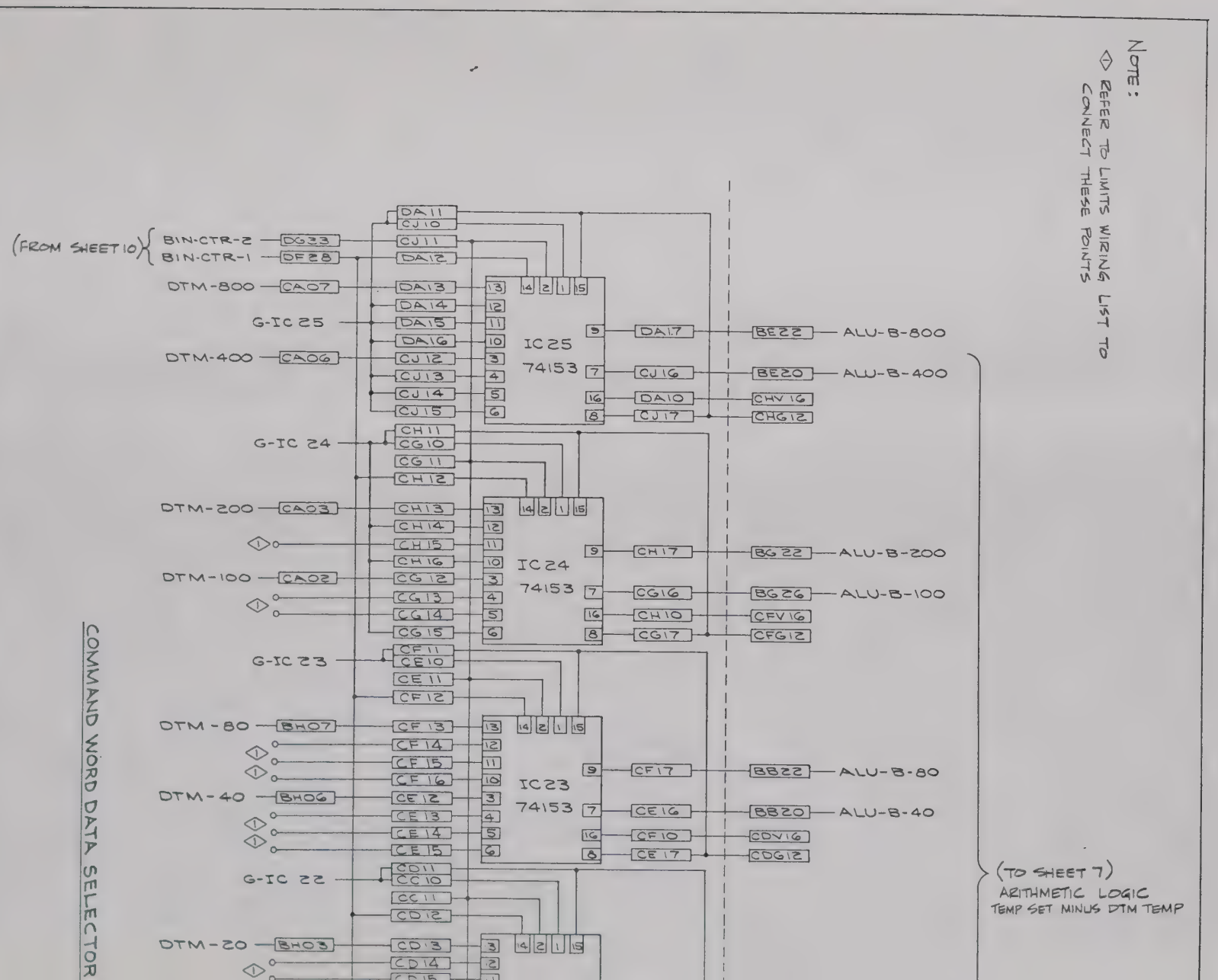
TORAGE

TEMPTRONIC

SCHEMATIC
(DIGITAL TEMP. CONTROL)

SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	B

SCALE N.A. SHEET 5 OF

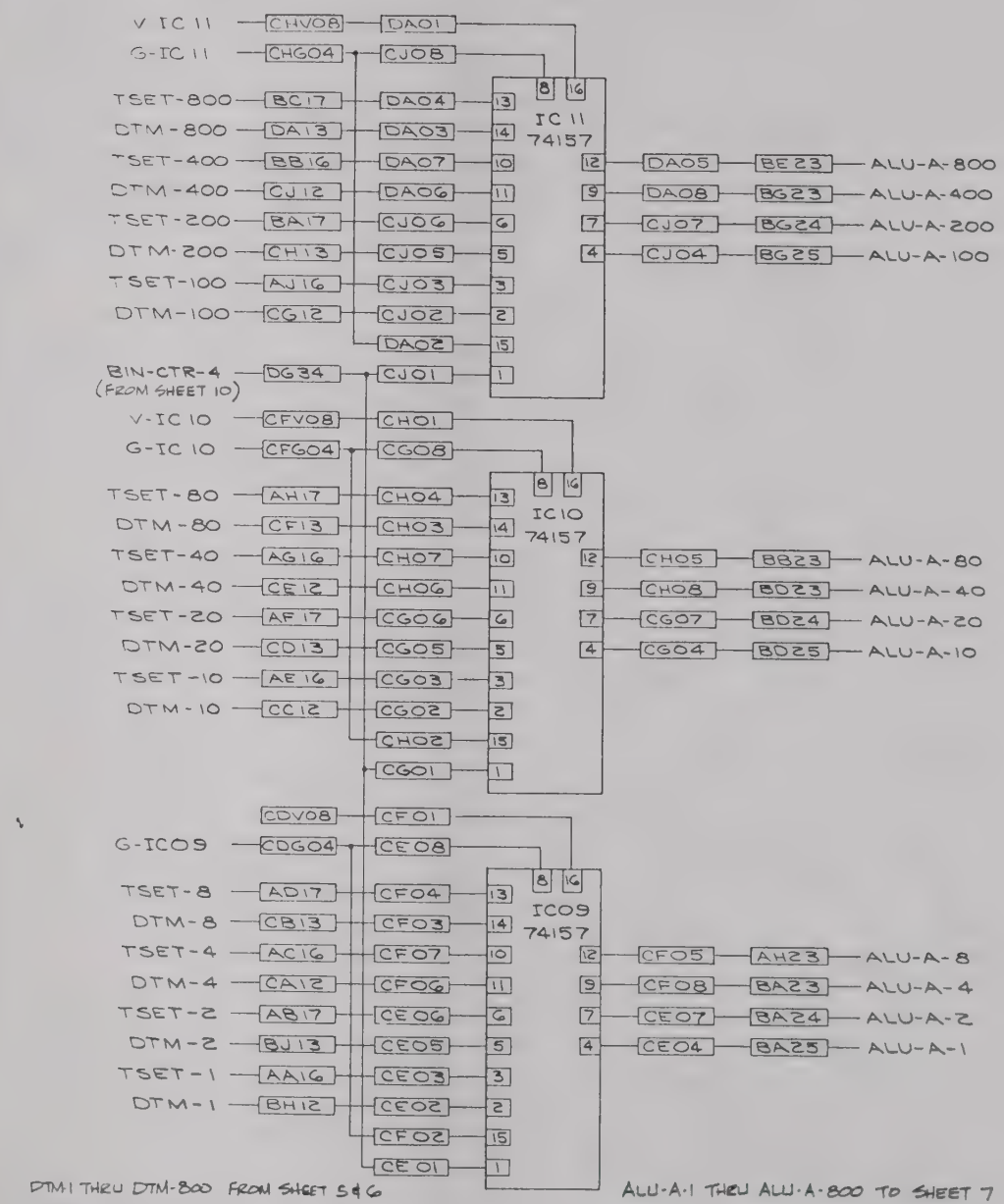

NOTE:
◇ REFER TO LIMITS WIRING LIST TO CONNECT THESE POINTS
COMMAND WORD DATA SELECTOR
(FROM SHEET 10)
BIN-CTR-2
BIN-CTR-1
DTM-800
G-IC 25
DTM-400
G-IC 24
DTM-200
DTM-100
G-IC 23
DTM-80
DTM-40
G-IC 22
DTM-20
IC 25 74153
IC 24 74153
IC 23 74153
ALU-B-800
ALU-B-400
ALU-B-200
ALU-B-100
ALU-B-80
ALU-B-40
(TO SHEET 7)
ARITHMETIC LOGIC
TEMP SET MINUS DTM TEMP

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 656	1-31-78	

TEMPTRONIC

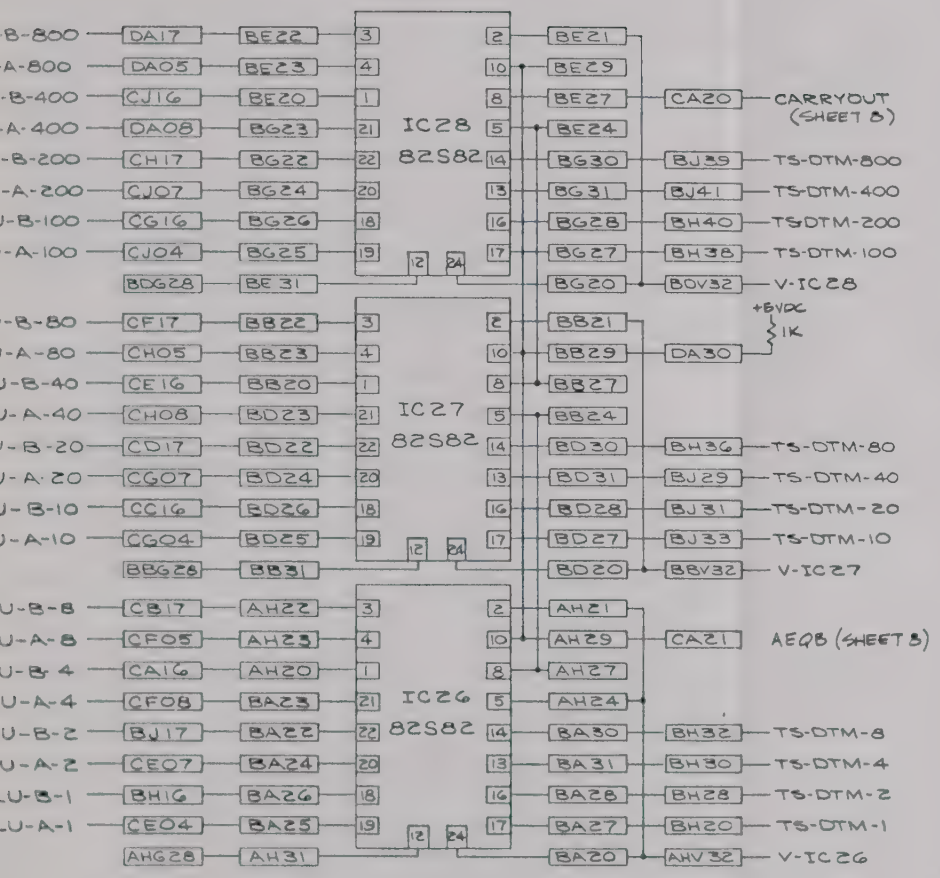
SCHEMATIC
(DIGITAL TEMP CONTROL)

SIZE	CODE IDENT NO	DRAWING NO.	REV
D		2173	A
SCALE NA		SHEET 6 OF 11	



TEMP SET/ DTM TEMP DATA SELECTOR

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 6056	1-31-78	



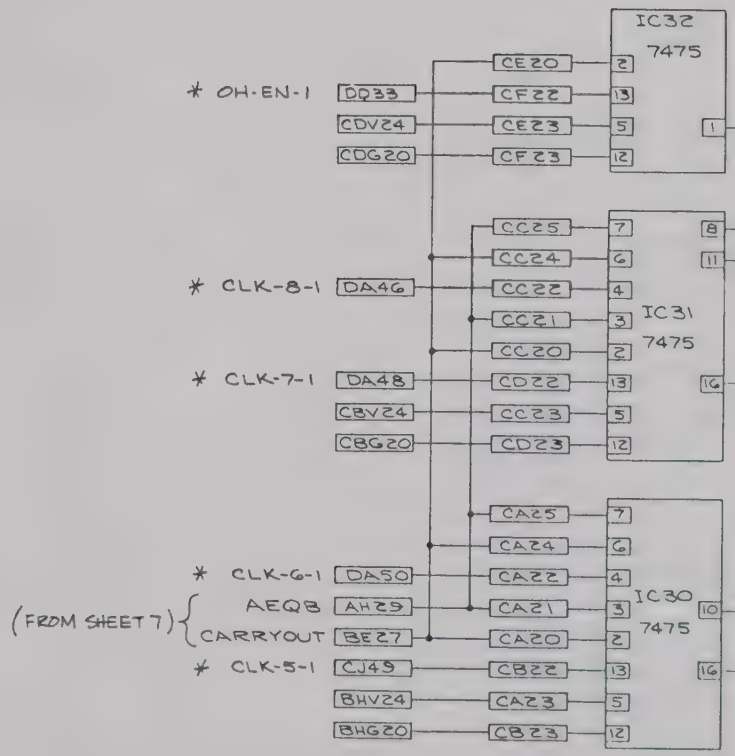
ARITHMETIC LOGIC - TEMP SET MINUS DTM TEMP

THRU ALU-A-800 FROM SHEET 6 TEMP SET/DTM TEMP DATA SELECTOR
THRU ALU-B-800 FROM SHEET 6 COMMAND WORD DATA SELECTOR

TEMPTRONIC

SCHEMATIC
(DIGITAL TEMP. CONTROL)

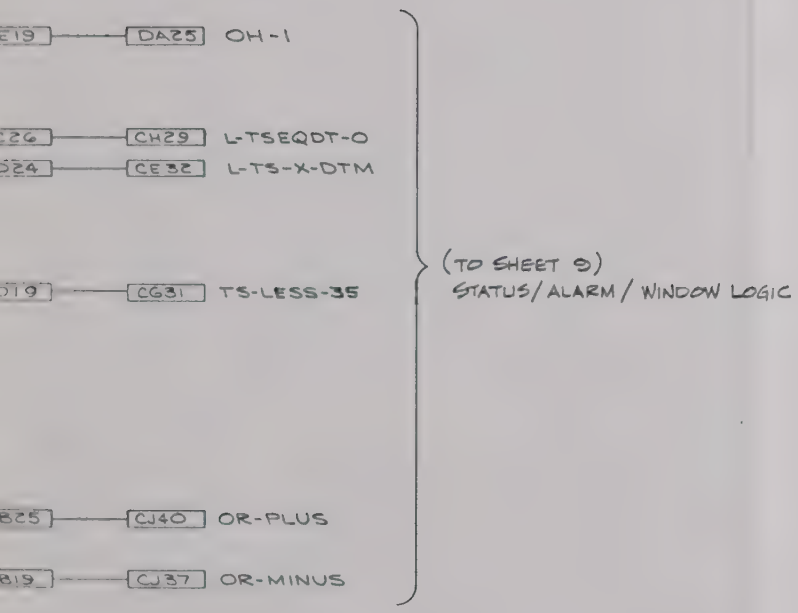
SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	A
SCALE NA			SHEET 7 OF 11



COMMAND STORAGE

* FROM SHEET 10 SYSTEM TIMING

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REVISED PER DCN 656	1-31-78	
	B	REVISED PER DCN 1411	9/12/	J.B.

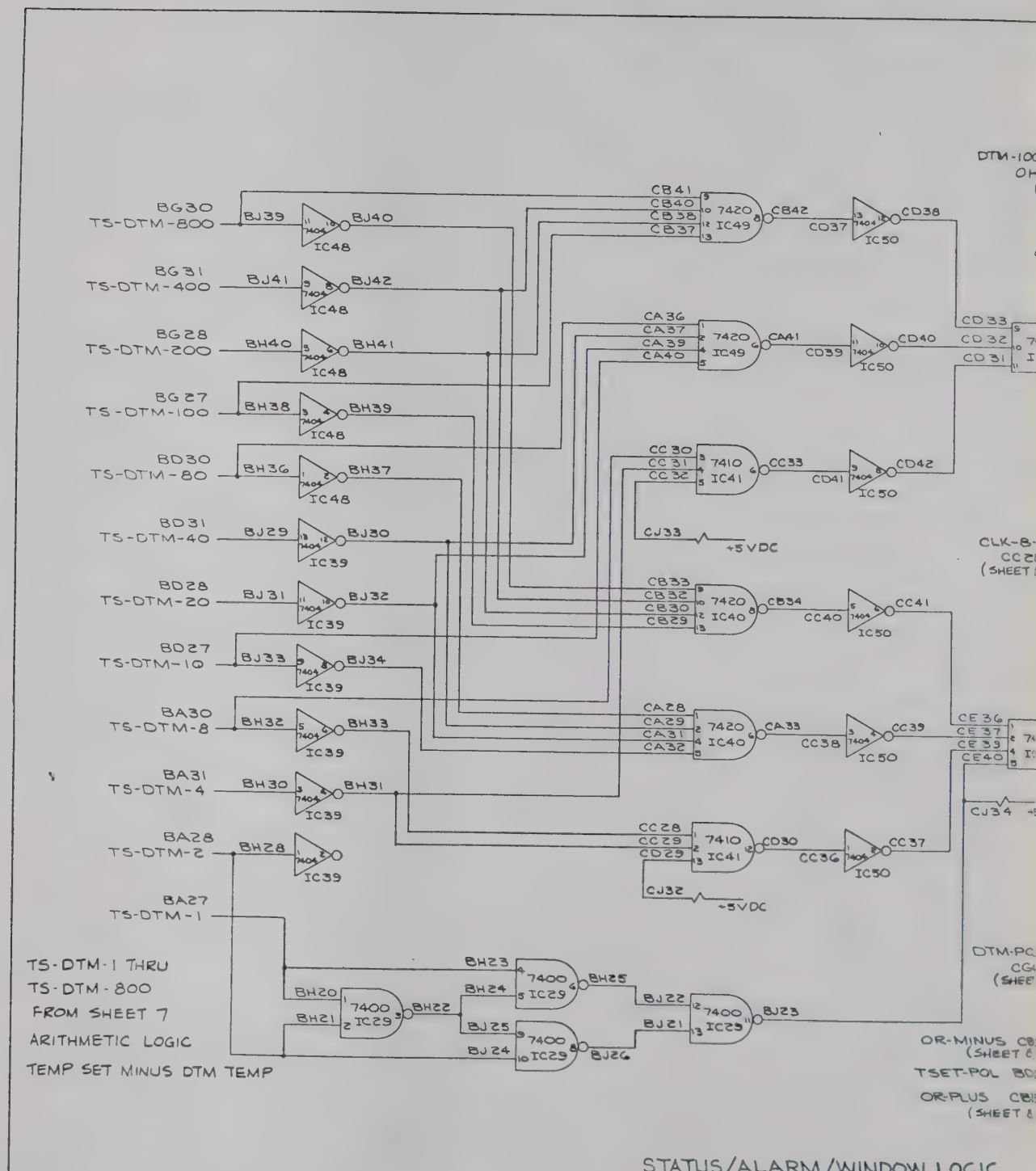


TEMPTROL

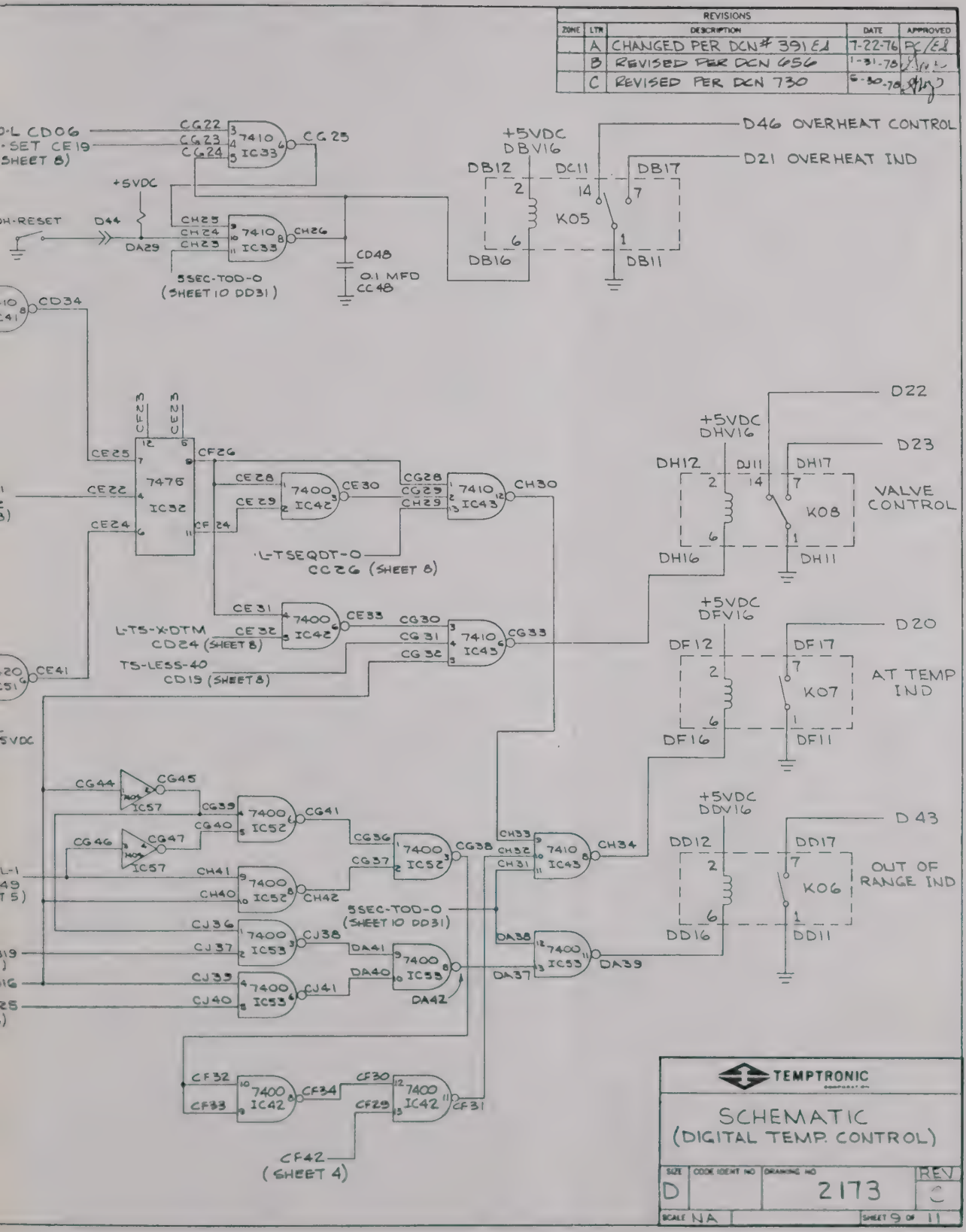
SCHEMATIC
(DIGITAL TEMP. CONTROL)

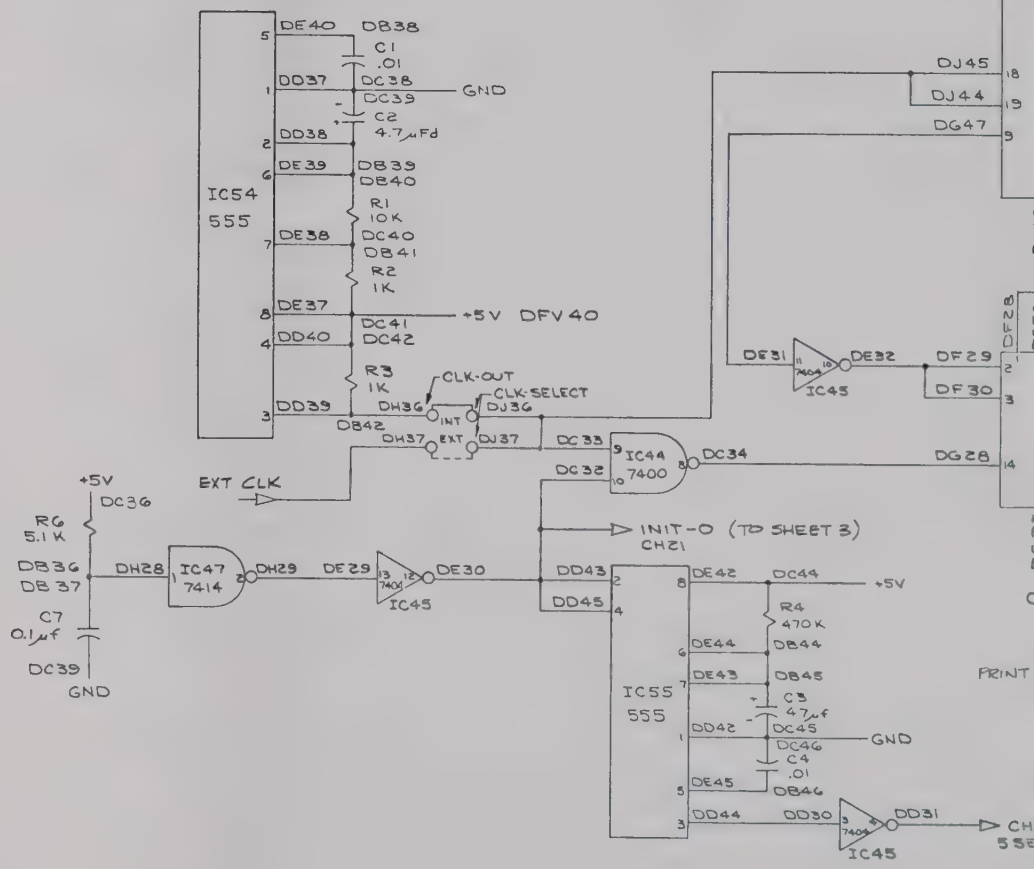
SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	B

SCALE NA | SH 18 OF 11



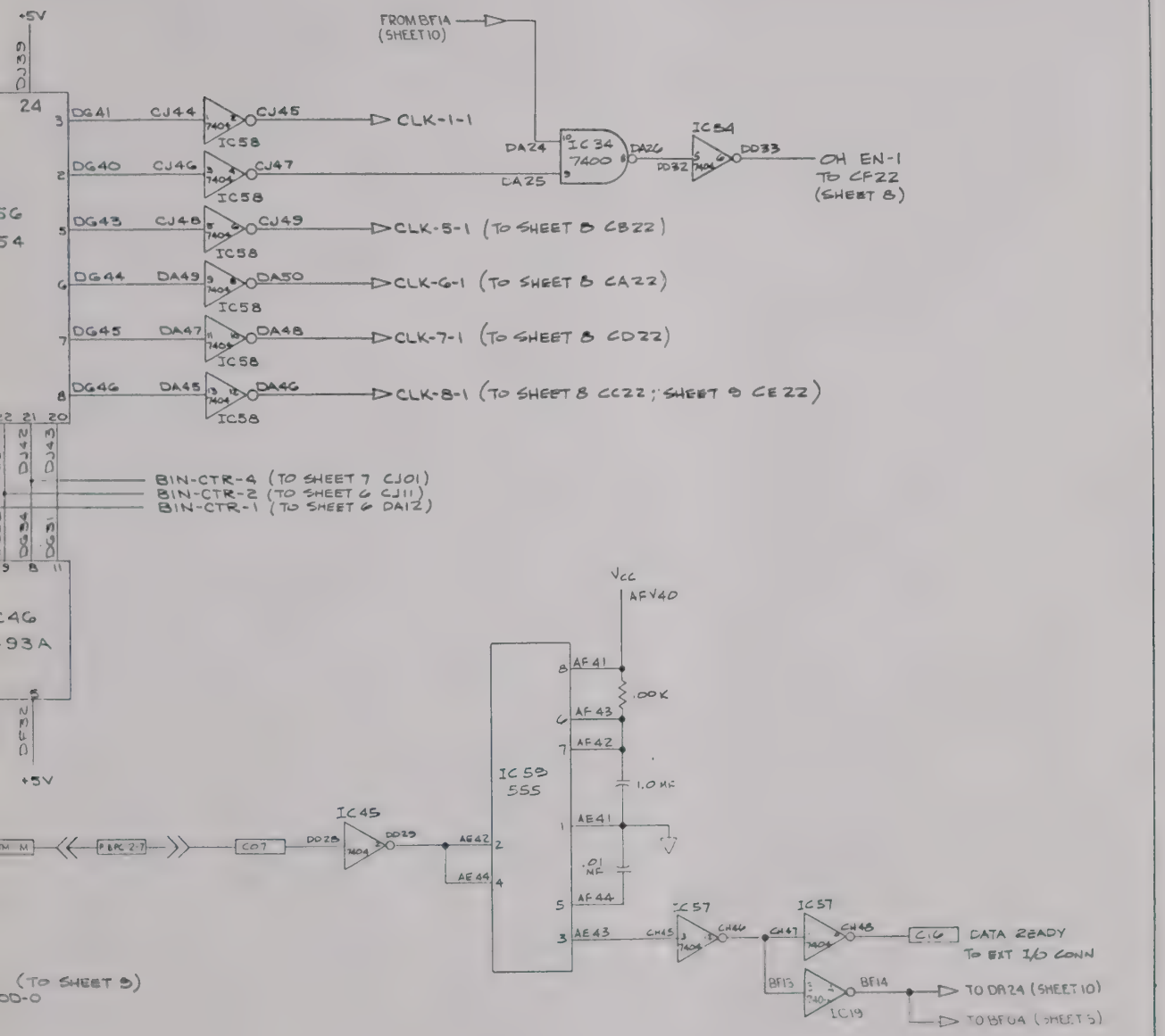
STATUS/ALARM/WINDOW LOGIC


REVISIONS
ZONE | LTR | DESCRIPTION | DATE | APPROVED
A | CHANGED PER DCN # 391 Ed | 7-22-76 | PC/Ed
B | REVISED PER DCN 656 | 1-31-78
C | REVISED PER DCN 730 | 6-30-78
D46 OVERHEAT CONTROL
D21 OVERHEAT IND
+5VDC
DBV16
DB12
DC11
DB17
DB16
DB11
K05
D44
DA29
CD48
0.1 MFD
CC48
5SEC-TOD-0
(SHEET 10 DD31)
CD34
CE25
CF26
CE22
CE24
7476
IC32
CE28
CE29
CE30
CG28
CG29
CH29
CH30
L-TSEQDT-0
CC26 (SHEET 8)
D22
D23
+5VDC
DHV16
DH12
DJ11
DH17
DH16
DH11
K08
VALVE CONTROL
CE31
CE32
CE33
CG30
CG31
CG32
CG33
L-TS-X-DTM
CD24 (SHEET 8)
TS-LESS-40
CD15 (SHEET 8)
CE41
+5VDC
DFV16
DF12
DF17
DF16
DF11
K07
D20
AT TEMP IND
CG44
CG45
CG46
CG47
IC57
CG39
CG40
CG41
CG36
CG37
CG38
CH41
CH40
CH42
CJ36
CJ37
CJ38
CJ39
CJ40
CJ41
DA40
DA41
DA42
IC52
IC53
5SEC-TOD-0
(SHEET 10 DD31)
CH33
CH32
CH31
CH34
DA38
DA37
DA39
+5VDC
DDV16
DD12
DD17
DD16
DD11
K06
D43
OUT OF RANGE IND
CF32
CF33
CF34
CF30
CF29
CF31
IC42
CF42
(SHEET 4)
TEMPTRONIC
SCHEMATIC
(DIGITAL TEMP. CONTROL)
SIZE D
CODE IDENT NO
DRAWING NO 2173
REV C
SCALE NA
SHEET 9 OF 11



SYSTEM TIMING

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	CHANGED PER DCN # 391 E2	7-22-76	PC/E8
	B	REVISED PER DCN 656	1-31-73	
	C	REVISED PER DCN 1685	11-3-81	

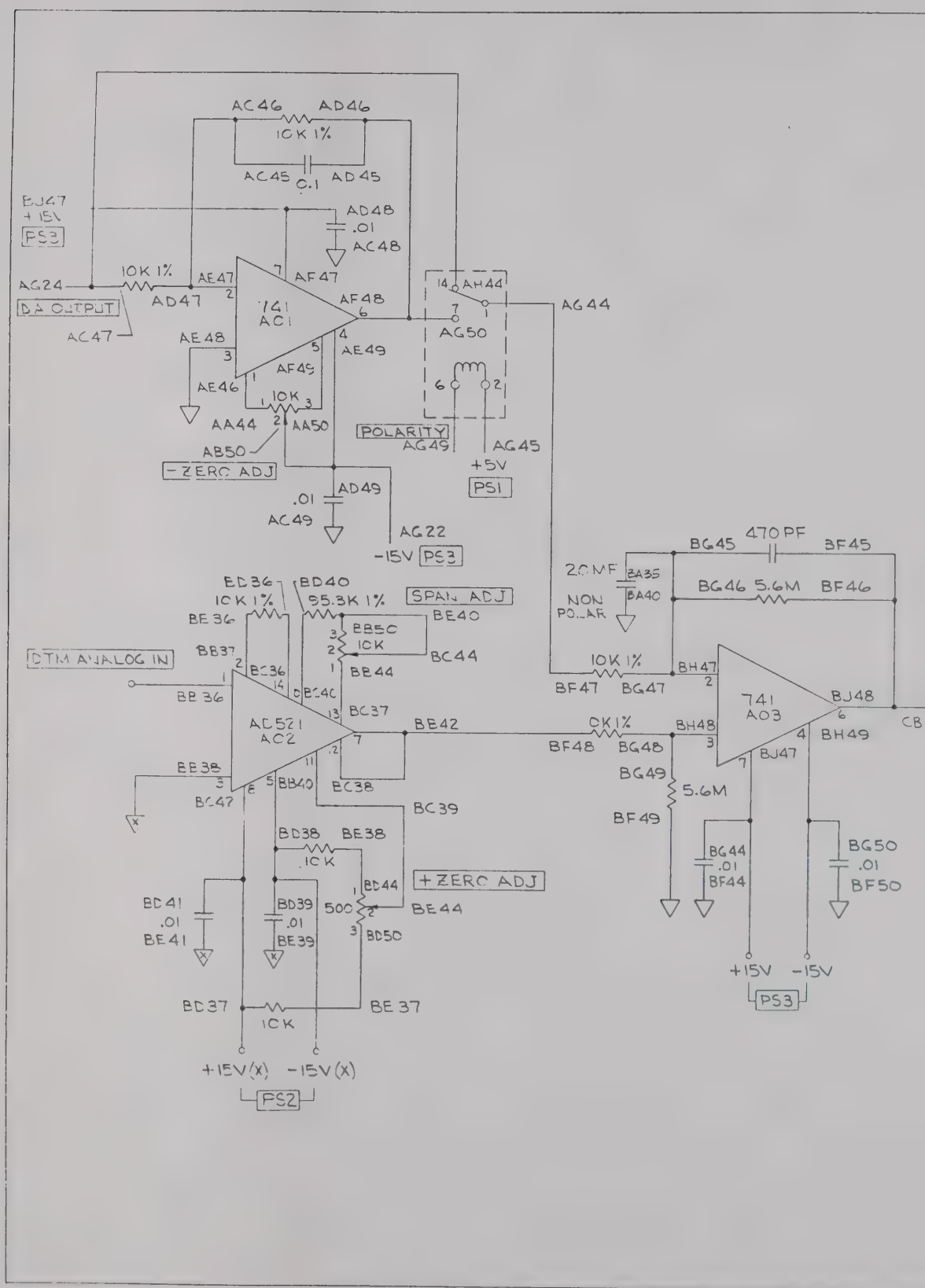


TEMP RONIC

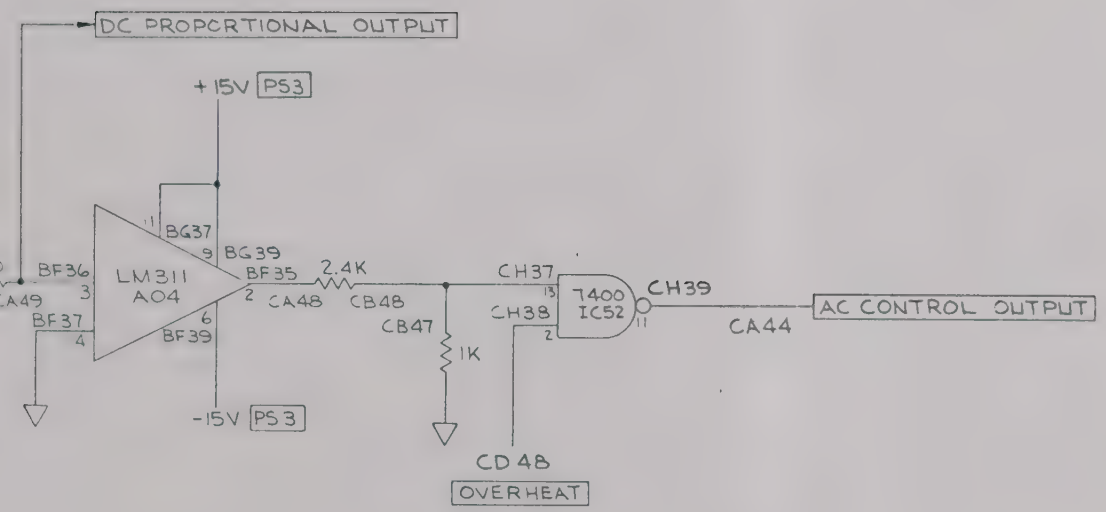
SCHEMATIC
DIGITAL TEMP. CONTROL)

SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	C

SCALE NA SHEET 10 OF 11


AC46
AD46
10K 1%
AC45
0.1
AD45
BJ47
+15V
PS3
AD48
.01
AC48
AG24
10K 1%
AE47
AF47
AD47
DA OUTPUT
AC47
741
AC1
AF48
AG44
AH44
AG50
AE48
AE49
AF49
AE46
10K
AA44
AA50
POLARITY
AG49
AG45
+5V
PS1
AB50
-ZERO ADJ
.01
AD49
AC49
AG22
-15V
PS3
BD36
BD40
10K 1%
95.3K 1%
SPAN ADJ
BE36
BE40
BB37
BB36
BB38
BC47
BB50
10K
BC44
BE44
DTM ANALOG IN
AD521
AC2
BC36
BC40
BC37
BE42
BC38
BB40
BC39
BD38
BE38
.1CK
BD44
+ZERO ADJ
BD41
.01
BE41
BD39
.01
BE39
500
BE44
BD50
BD37
1CK
BE37
+15V(X)
-15V(X)
PS2
BG45
470 PF
BF45
2.0MF
BA35
BA40
NON
POLAR
BG46
5.6M
BF46
10K 1%
BF47
BG47
BH47
741
A03
BJ48
BH49
BJ47
CK 1%
BF48
BG48
BH48
BG49
5.6M
BF49
BG44
.01
BF44
BG50
.01
BF50
+15V
-15V
PS3

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	CHANGED PER DCN # 391 ES	7-22-76	PC/ES
	B	REVISED PER DCN 730	5-23-78	



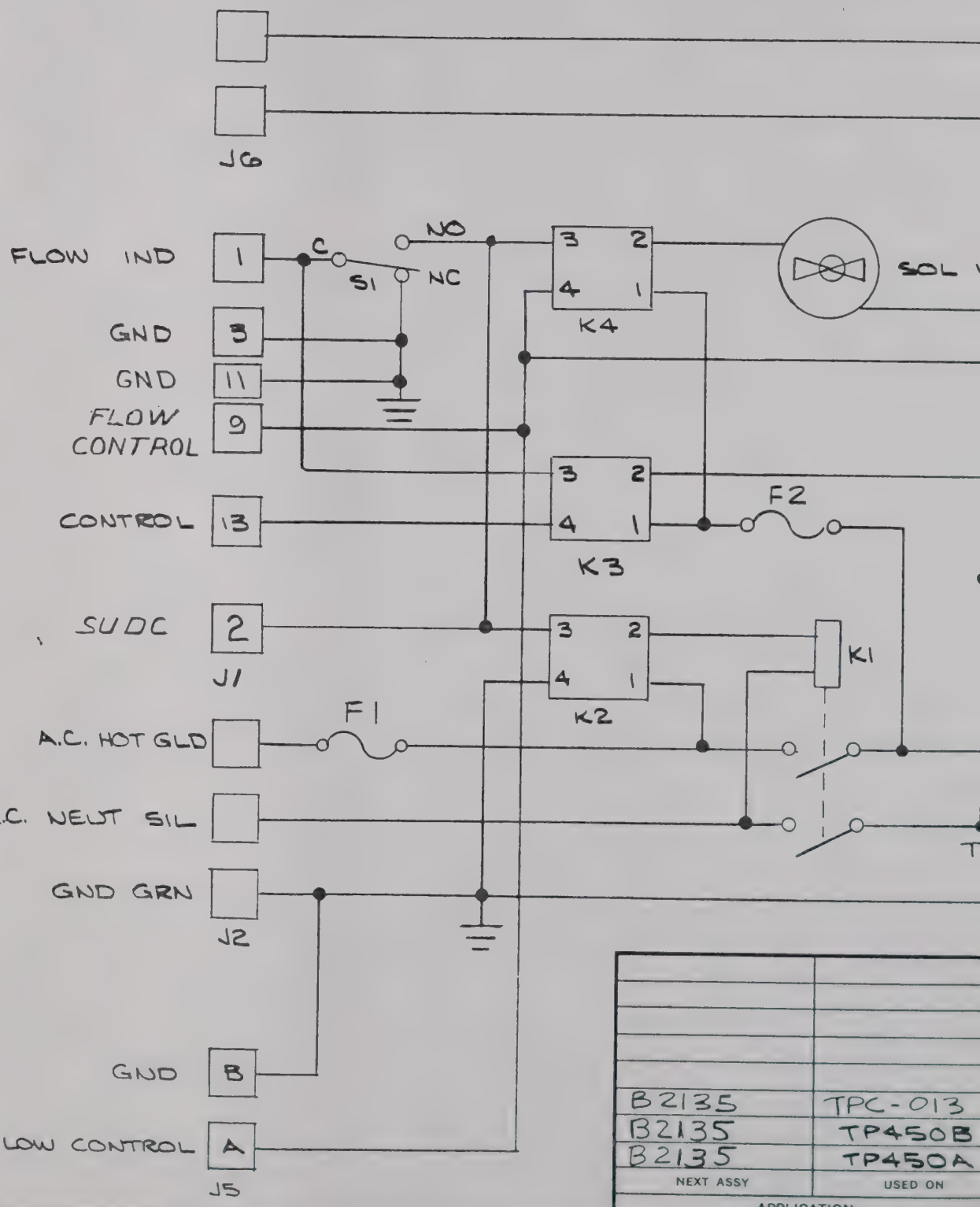
TEMPTRONIC

SCHEMATIC
(DIGITAL TEMP CONTROL)

SIZE	CODE IDENT NO	DRAWING NO	REV
D		2173	B

SCALE NA SHEET 1 OF 11

	D	REVISED PER DCN 9

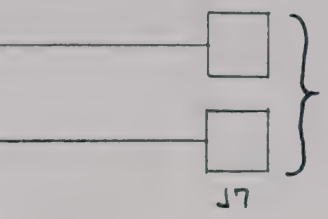


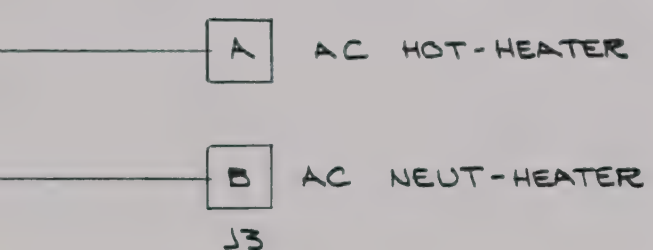
B2135	TPC-013
B2135	TP450B
B2135	TP450A
NEXT ASSY	USED ON
APPLICATION	

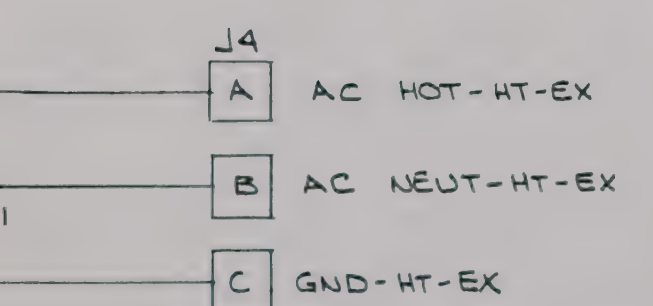
2-20-79	N.O.	

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
–	A	REDRAWN	12-22-76	DGB
	B	REVISED PER DCN 666	2/23/78	
	C	REVISED PER DCN 895	12-7-78	







UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± ±
.XXX ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

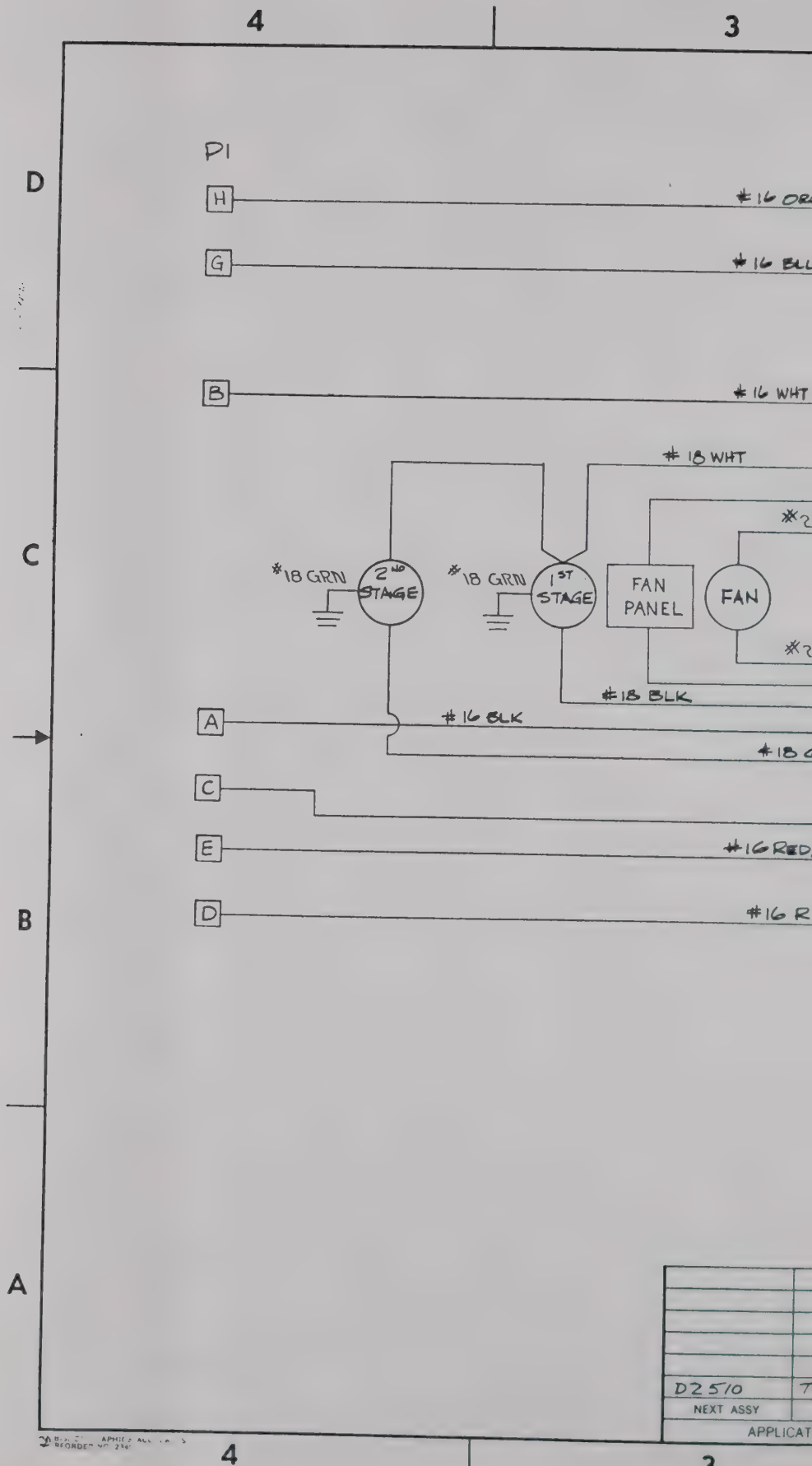
APPROVALS	DATE
DRAWN G. EAGER	12-22-76
CHECKED D. BUTCHER	12-22-76

TEMPTRONIC

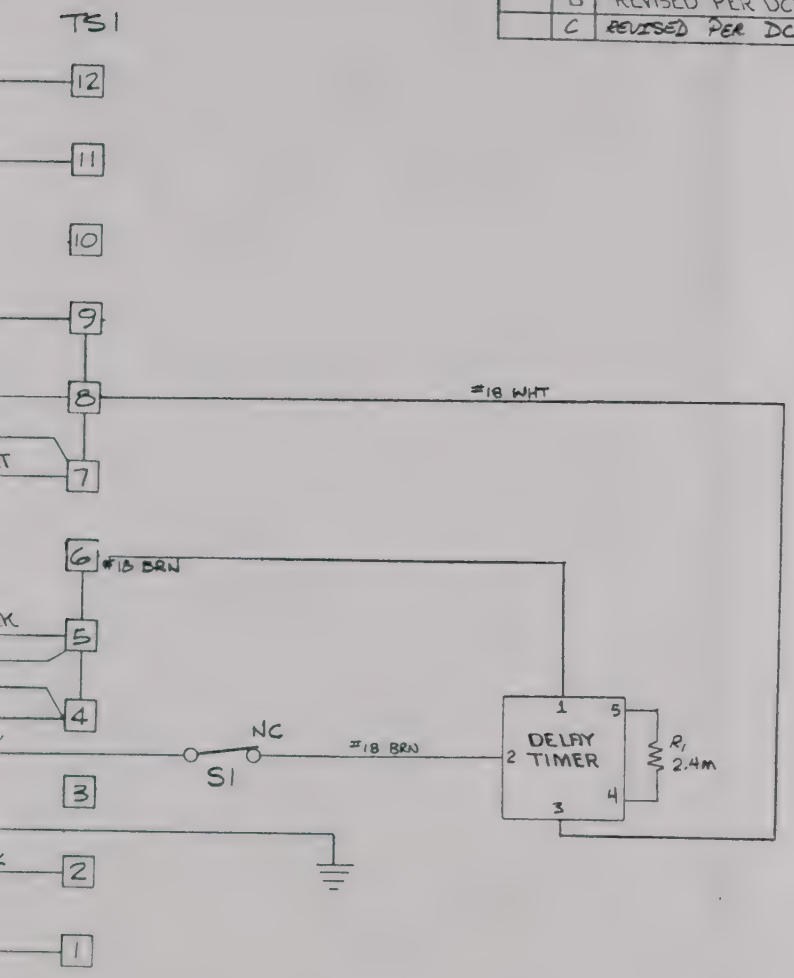
POWER CONTROL (SCHEMATIC)

SIZE	CODE IDENT NO.	DRAWING NO.	REV
B		2062	D

SCALE NONE SHEET 1 OF 1


4
3
P1
H
#16 OR
G
#16 BL
B
#16 WHT
#18 WHT
*18 GRN
2ND STAGE
*18 GRN
1ST STAGE
FAN PANEL
FAN
#18 BLK
A
#16 BLK
C
E
#16 RED
D
#16 R
D2510
NEXT ASSY
APPLICAT
4
3

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 806	8-24-78	
	B	REVISED PER DCN 1286	4-30-80	
	C	REVISED PER DCN 1469	2-6-81	



QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO

APPROVALS	DATE
DRAWN [illegible] TAMIYASU	5-18-77
CHECKED	
[illegible]	13/77

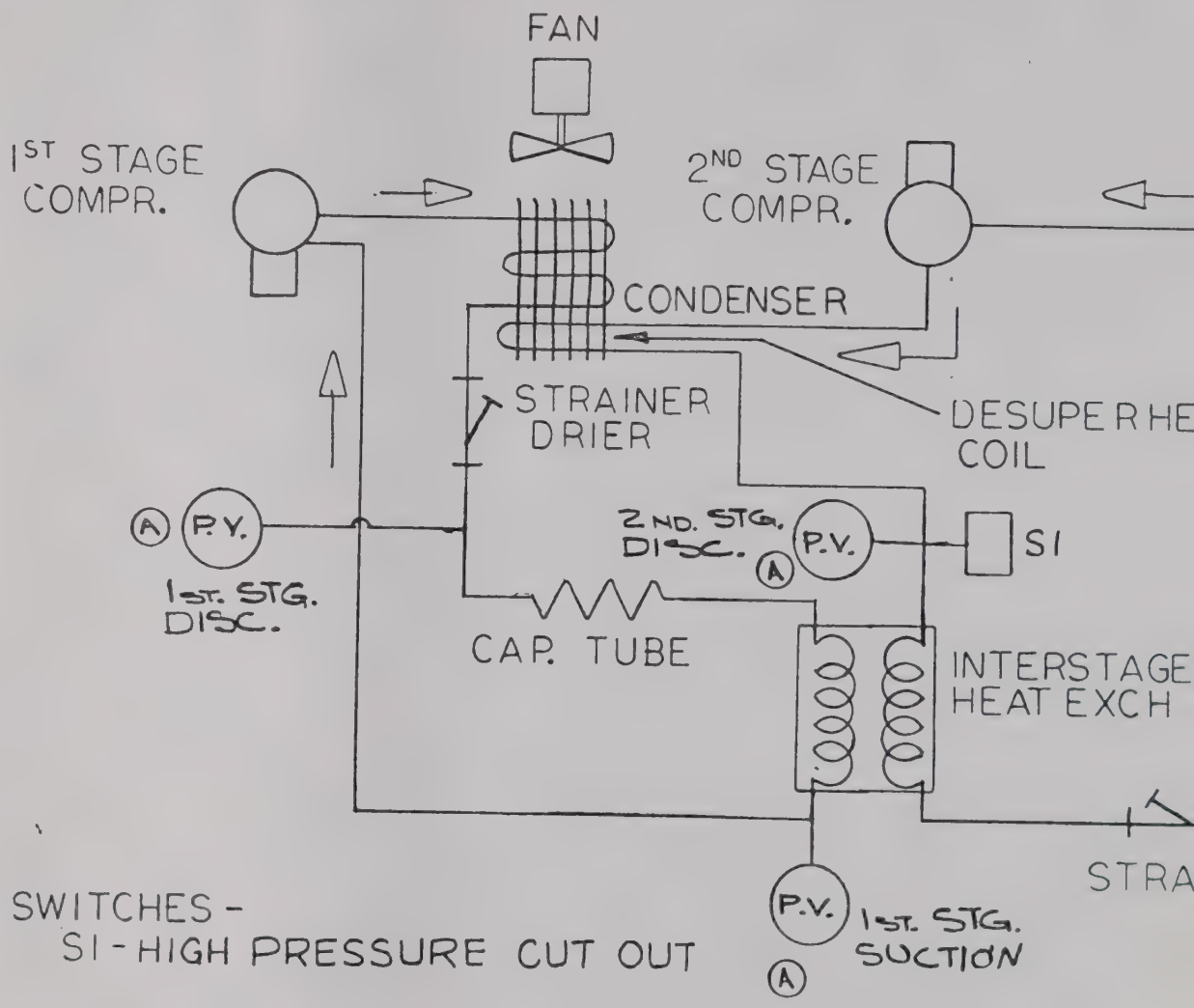
TEMPTRONIC

WIRING DIAGRAM
CASCADE HEAT EXCHANGER

SIZE	CODE IDENT NO	DRAWING NO	REV
C		2586	C

SCALE —

SHEET 1 OF 1



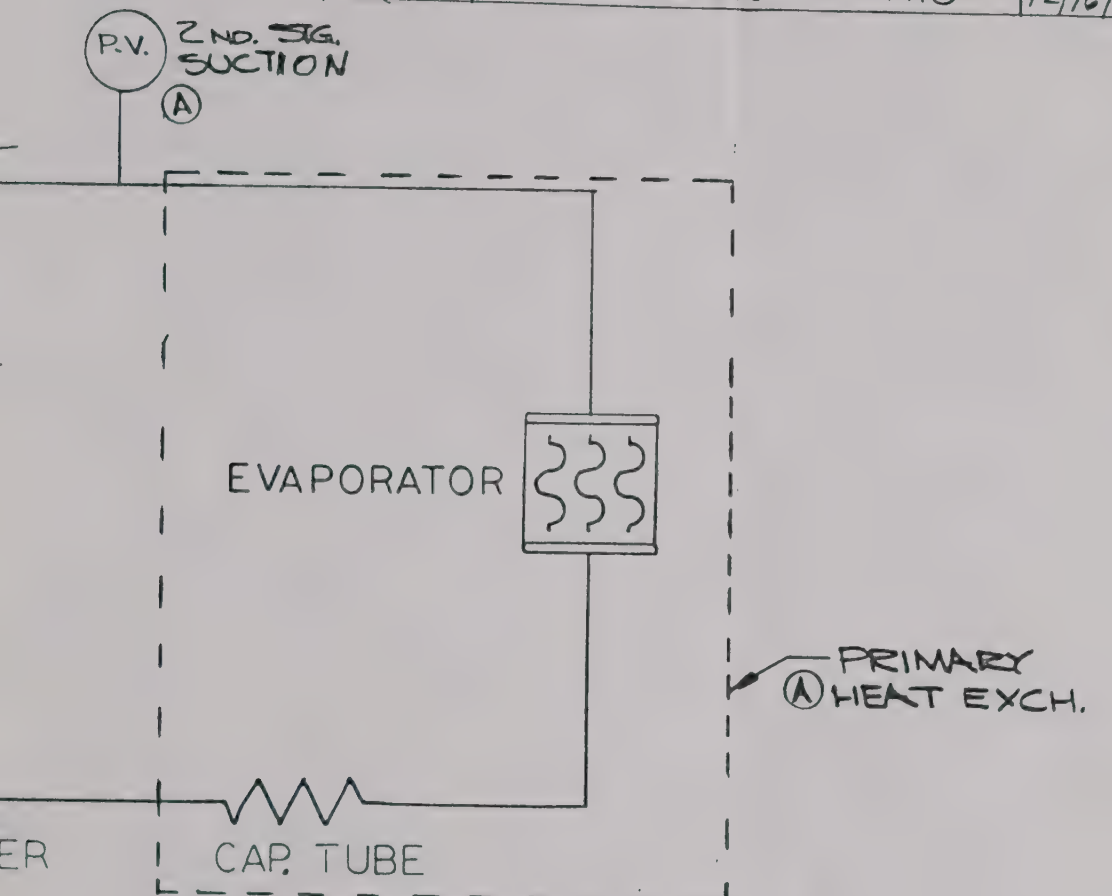
SWITCHES -
S1 - HIGH PRESSURE CUT OUT

REFRIGERANTS -
1ST STG. - R22
2ND STG. - R170 (ETHANE)

D2510	THX 14
NEXT ASSY	USED ON
APPLICATION	

BISHOP GRAPHICS/ACCUPRESS REORDER NO 2348

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN #644	1-12-78	E.M.
	B	REVISED PER DCN 1718	12/16/81	M.O.



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± ± .XXX ±

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

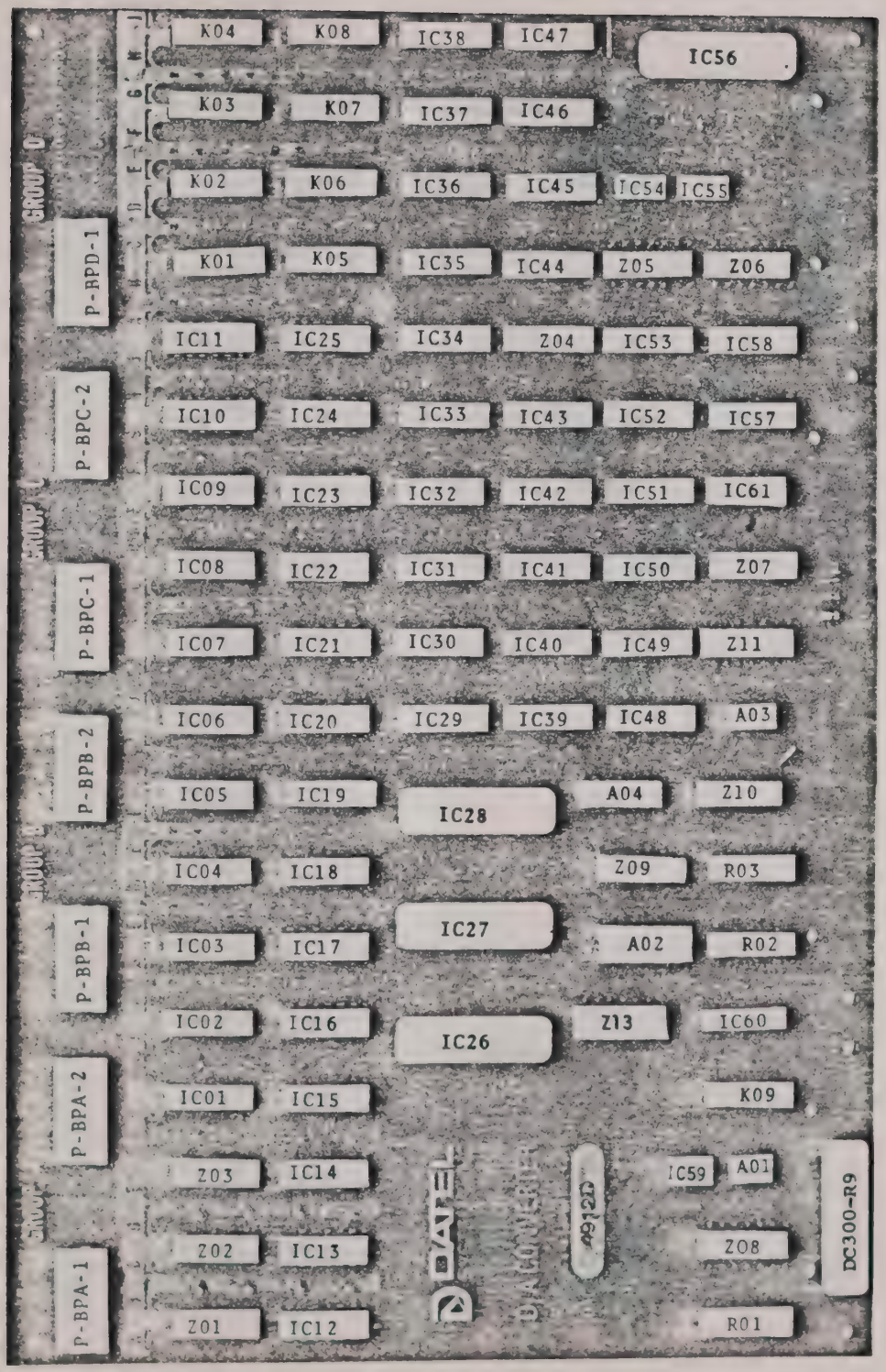
APPROVALS	DATE
DRAWN BAGER	12/26
CHECKED	
G. Eagen	8(7)

TEMPTRONIC

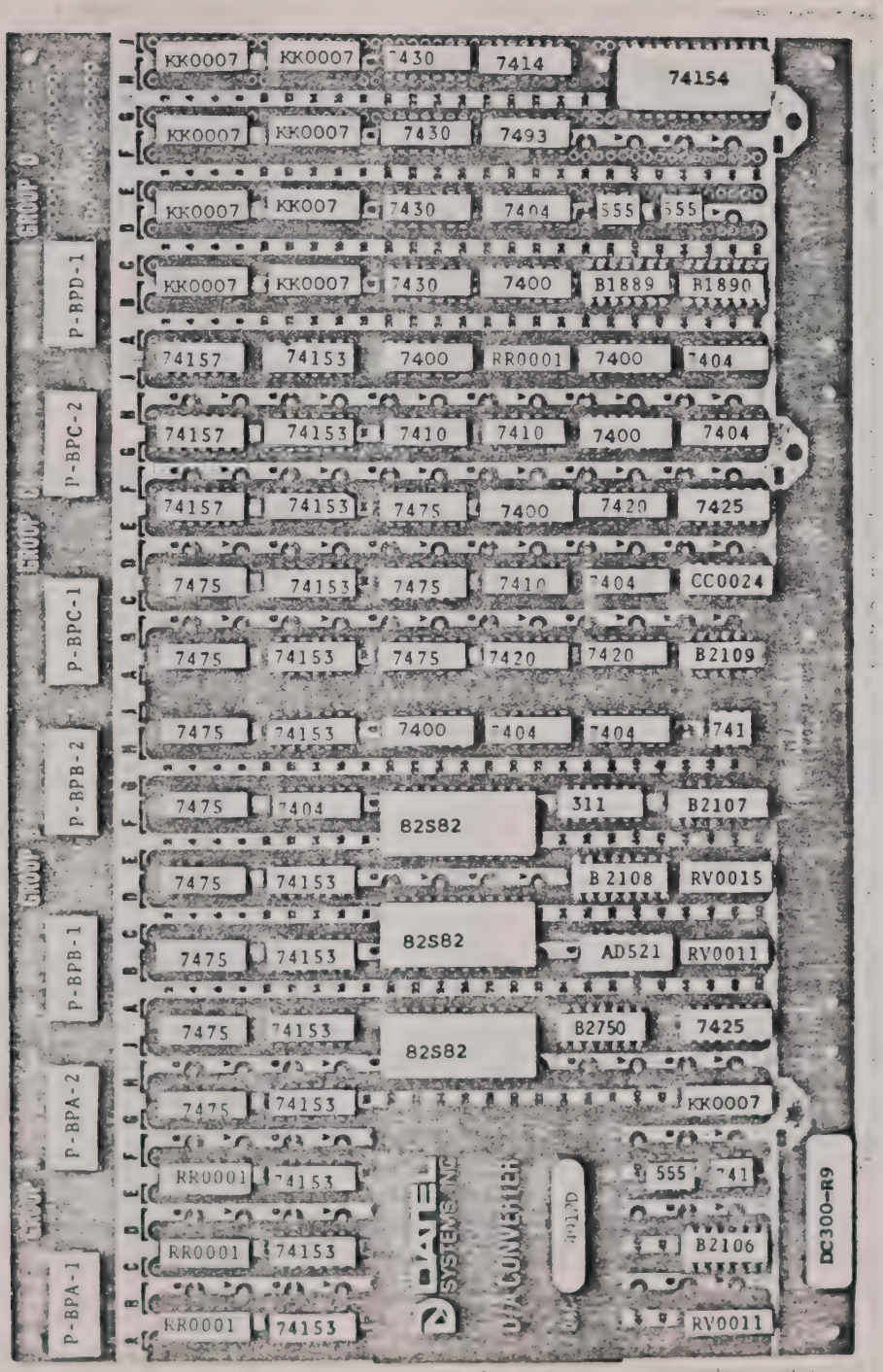
PIPING SCHEMATIC CASCADE HEAT EXCHANGER

SIZE	CODE IDENT NO.	DRAWING NO.	REV
B		2585	8

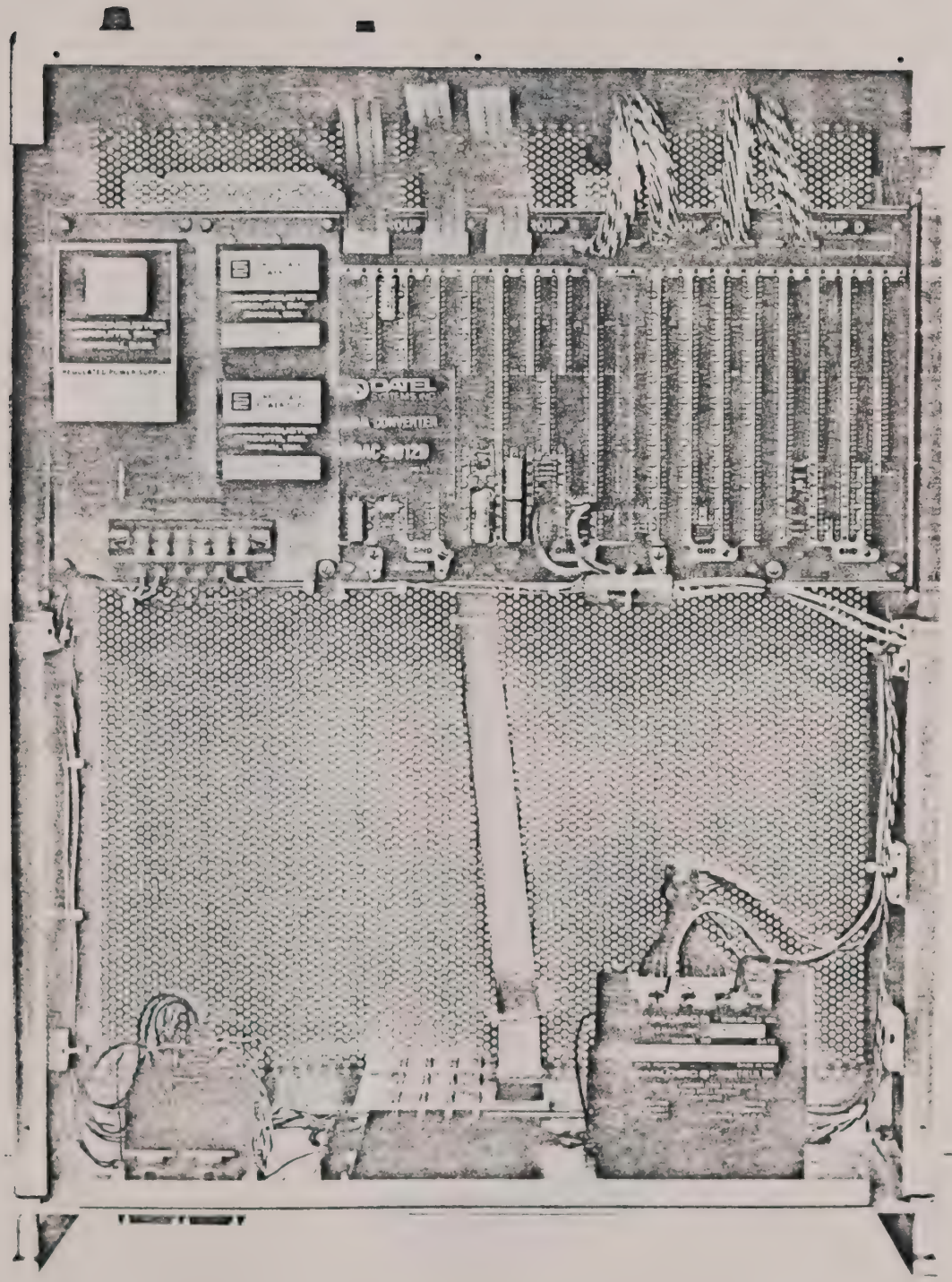
SCALE NA SHEET 1 OF 1



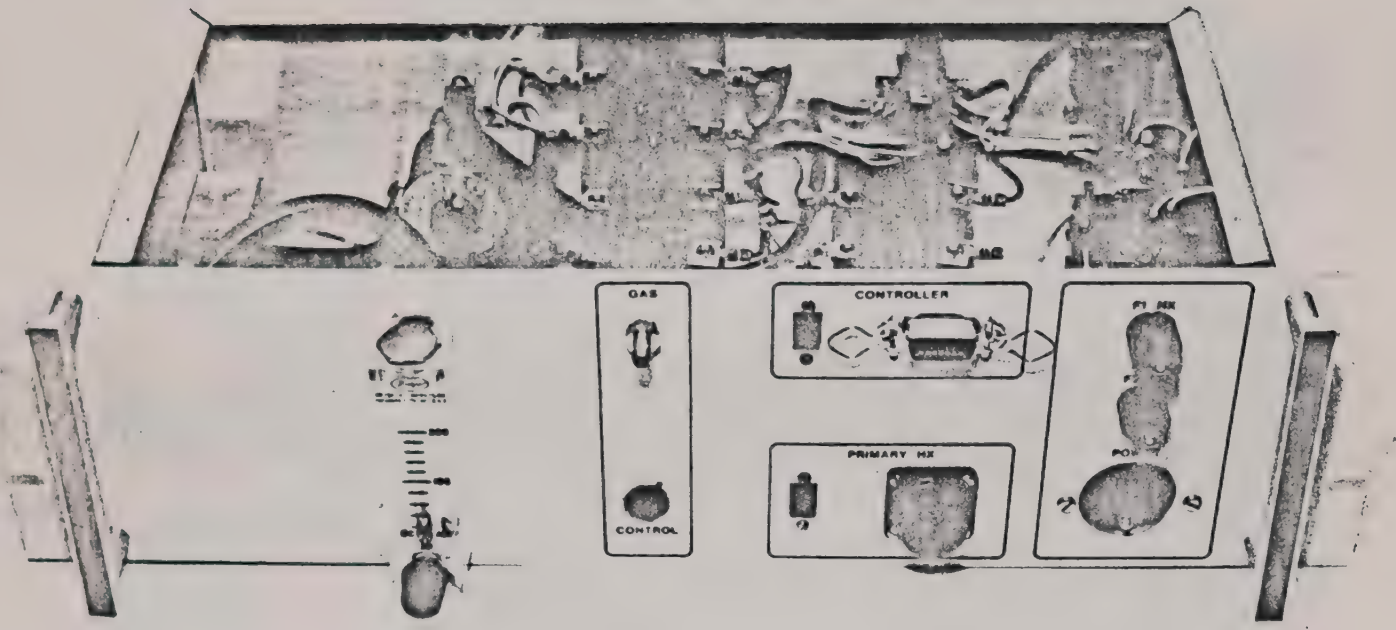
Back plane 1 with schematic references.



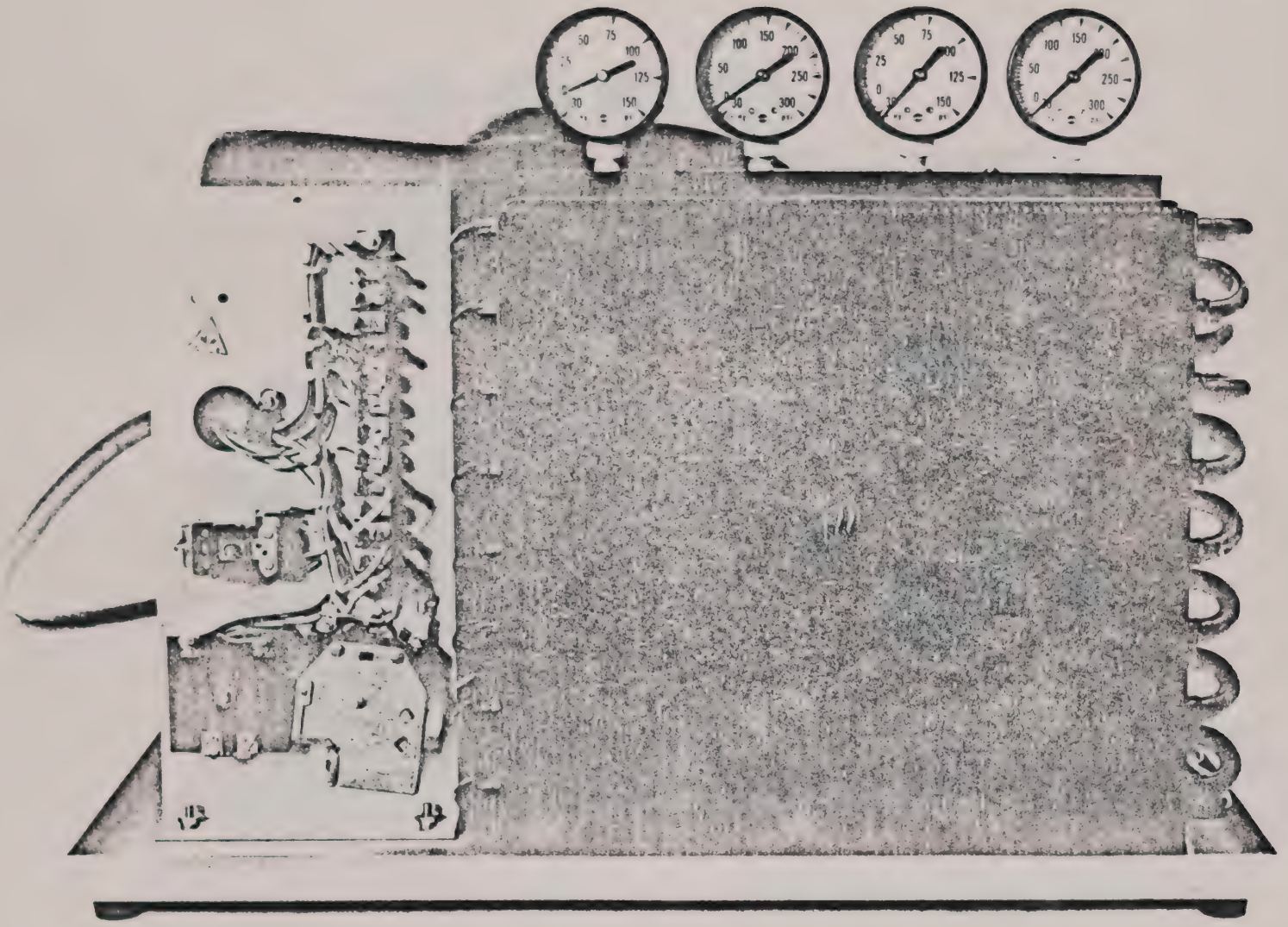
Back plane 2 with device types.



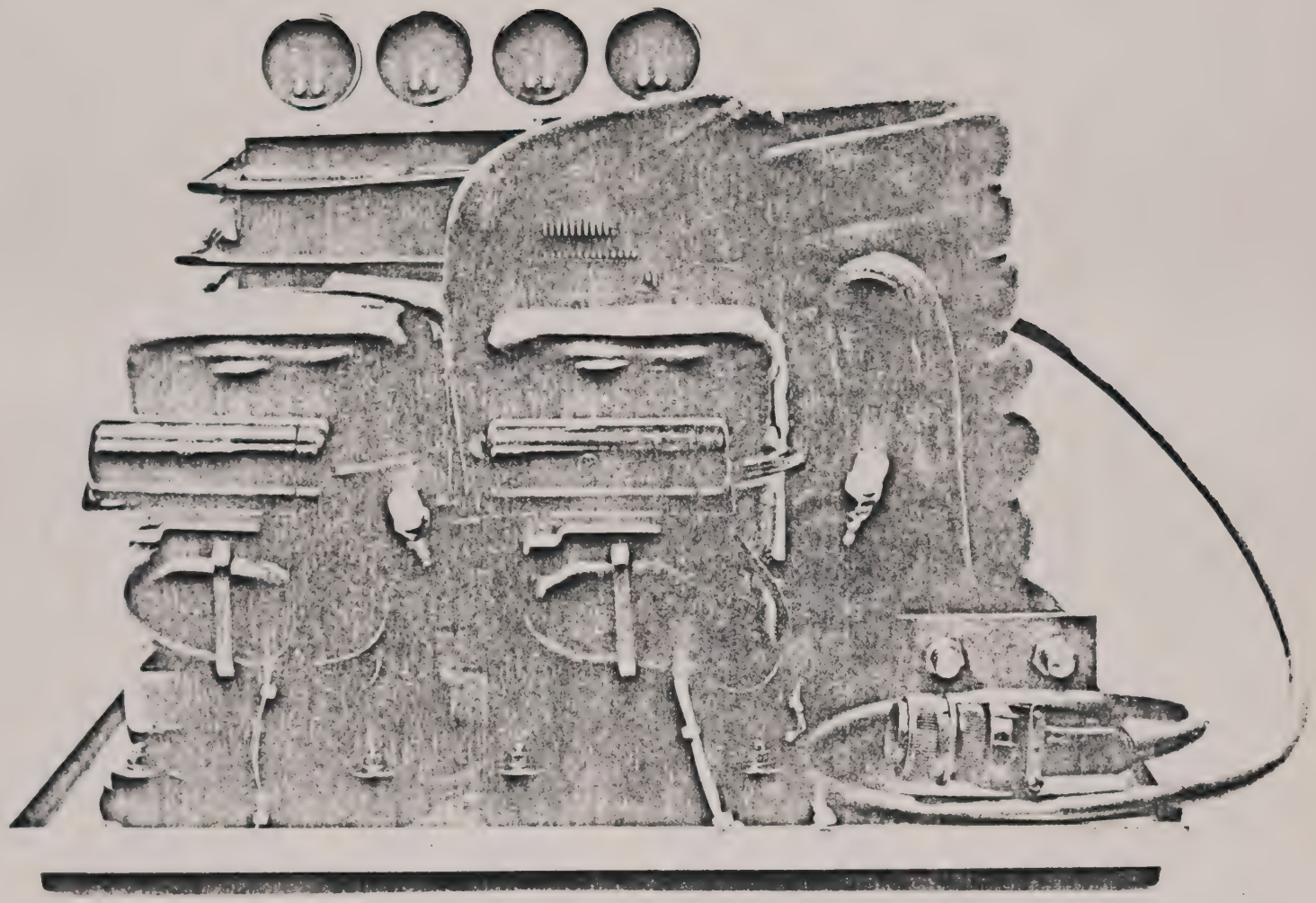
Interior of digital controller.



Interior of power control.



Secondary heat exchanger, front view.



Secondary heat exchanger, rear view.

APPENDIX B

PHYSICAL PRINCIPLES OF THERMOSTREAM SYSTEMS

B.1 INTRODUCTION

Temptronic ThermoStream systems are precision tools. As is the case with all precision tools, they can be used to maximum benefit only if certain fundamental physical principles concerning their operation are fully considered by the user.

Following is a brief discussion concerning the important physical principles as they relate to ThermoStream usage.

B.2 TEMPERATURE CONTROL

Temptronic ThermoStream systems provide temperature controlled gas which can be conveniently used to provide test ambients at specific temperatures. It is important to remember that the test specimen is outside the ThermoStream temperature control loop and its temperature is controlled only secondarily by the ThermoStream air.

B.3 HEAT TRANSFER

A ThermoStream transfers heat to and from a test specimen by forced air convection. Heat transfer requires time; thus test specimen temperature changes will always lag ThermoStream air temperature changes, as is illustrated graphically in Figure B-1.

Various test system variables affect the test specimen stabilization temperature and the time required to reach this stabilization temperature. The most significant of these variables are:

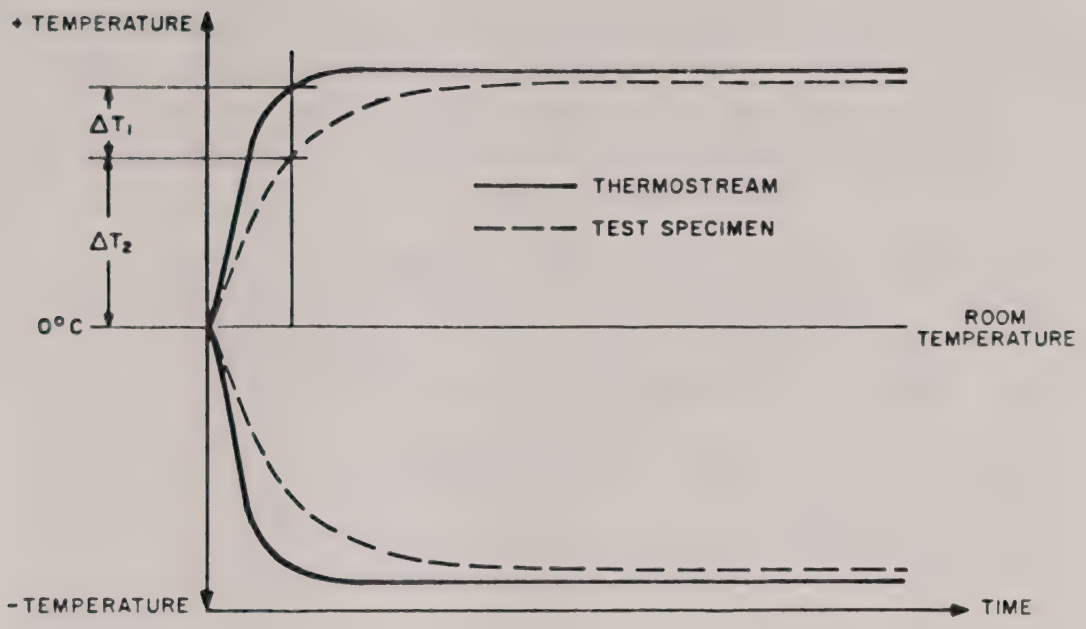


Figure B-1. ThermoStream air temperature and test specimen temperature vs time.

1. The temperature difference between the ThermoStream air and the test specimen continually changes until the test specimen reaches a stabilization temperature.

The greater the value of ΔT_1, the greater will be the forced convective heat transfer rate and the shorter will be the time for the test specimen to reach a stabilization temperature. Thus when ΔT_1 is large, the test specimen temperature will change more rapidly than when ΔT_1 is small.

2. The temperature difference between the test specimen and the room ambient temperature ΔT_2 continually increases until the test specimen reaches a stabilization temperature. The greater the value of ΔT_2 the greater will be the heat transfer losses to or from the test specimen and the longer the time will be to reach stabilization.

3. The largest heat transfer loss from the test specimen is via thermal conduction from the test specimen through its mounting to the room ambient temperature zone. This can be minimized through selection of low thermal conductivity materials, long thermal conduction paths, and small thermal conduction path areas.

4. The greater the mass in the test zone, the longer will be the time necessary to change its temperature between two limits. Though the test specimen mass is normally fixed, the masses of the fixturing in the test zone may be designed to minimize mass.

5. The greater the specific heat of the mass in the test zone, the longer the time will be to change its temperature between two limits. Specific heats of any fixturing in the test zone may be minimized through careful selection of low specific heat materials.

6. The better the thermal coupling between the temperature controlled air and the test specimen, the shorter will be the time required to change the test specimen temperature between two limits and the smaller the temperature difference will be between the test specimen and the air stream at temperature stabilization. In general, thermal coupling is maximized through fixturing which permits the maximum percentage of temperature controlled air to impinge on the test sample rather than being wasted in transferring heat to or from masses that do not require temperature control.

B.4 HIGH AND LOW TEMPERATURE CONSIDERATIONS

In using a ThermoStream to achieve temperatures in test specimens, the user must have fixturing which will limit high and low temperatures to a well-defined test zone so that temperature-sensitive parts of the remainder of the test setup are not damaged. This can be accomplished through fixture design incorporating long thermal paths through small areas of low thermal conductivity materials and by baffling to limit the high and low temperature air to only the test zone.

B.5 DEW POINT CONSIDERATIONS

In addition to the temperature considerations of the previous paragraphs, the user must apply a ThermoStream in a manner which will prevent or minimize condensation of moisture. Within the test zone, the air has a moisture content with a dew point below the temperature capability of a ThermoStream and no condensation will occur. Outside the test zone, however, condensation will occur if the temperature is below the dew point temperature of the ambient air. Where condensation can damage other parts of the test system, it must be minimized by 1) limiting times at low temperatures so that a damaging amount of condensation does not have sufficient time to form, or 2) by maintaining temperatures above the dew point by limiting thermal conduction (see paragraph B.4), and/or 3) by heating the subject areas.

APPENDIX C

UTILIZATION OF SILICONE FOAM INSULATION KIT

An insulation kit is supplied with each ThermoStream system. This kit is comprised of three sheets of silicone foam material (12x12x1/8, 12x12x1/4, and 12x12x1/2) and a tube of RTV adhesive. Proper application of these materials offers the user a simple and economical solution to the thermal interface problems created by the -60°C to +160°C environment within the test chamber.

A general problem encountered in the testing of components at both reduced and elevated temperatures is that of diminishing the heat transfer from the device under test within the chamber to the external test equipment. Since thermal conductivity is the mode of appreciable heat transfer, it is obvious that the use of materials which have low thermal conductivity is desirable.

Another form of heat transfer which must be considered is that of forced convection which occurs as a result of the gas flow turbulence inside the test chamber. Forced convection can be minimized so as to be negligible by sealing any gas leakage paths within the tester interface.

Silicone foam in sheet form combines the property of low thermal conductivity with the added features of elasticity and the ease with which it may be cut to fit snugly around a given component configuration, thereby forming a seal to minimize heat transfer due to forced convection.

Low-temperature testing presents the additional problem of possible condensation and/or icing at the tester interface. Due to the low dew point (less than -80°C) of the supply gas, condensation within the test chamber is not a problem. However,

thermal conduction and forced convection may cause condensation to appear on the cables and/or interconnecting devices to the test equipment which are normally located in a room environment having dew points in the order of 15°C. For those test procedures which require abbreviated soak times at reduced temperatures, condensation is minimal or nonexistent. However, long-term testing at reduced temperatures may require that additional precautionary measures be taken to prevent condensation, especially where the measurements of low-level voltages and currents are involved. Such precautions may simply require the use of additional silicone foam insulation or, in extreme cases, require that the area exhibiting condensation be flushed with room air or dry gas (e.g., nitrogen).

There is no universal solution to the thermal problems which may occur due to the variations in component geometry, the temperature range, and the soak times required for a specific test. However, the readily available and comparatively low cost silicone foam and RTV adhesive offer the user an effective interface solution to the majority of thermal problems. The user is encouraged to make use of the insulation kit to provide an economical alternative to that of an expensive dedicated interface. In the case of a specific application where the temperature range and soak time is defined, the Temptronic engineering staff would welcome the opportunity to assist the ThermoStream user in the design of a custom interface.

A typical design of an interface using the silicone foam insulation kit is shown in Figure C-1.

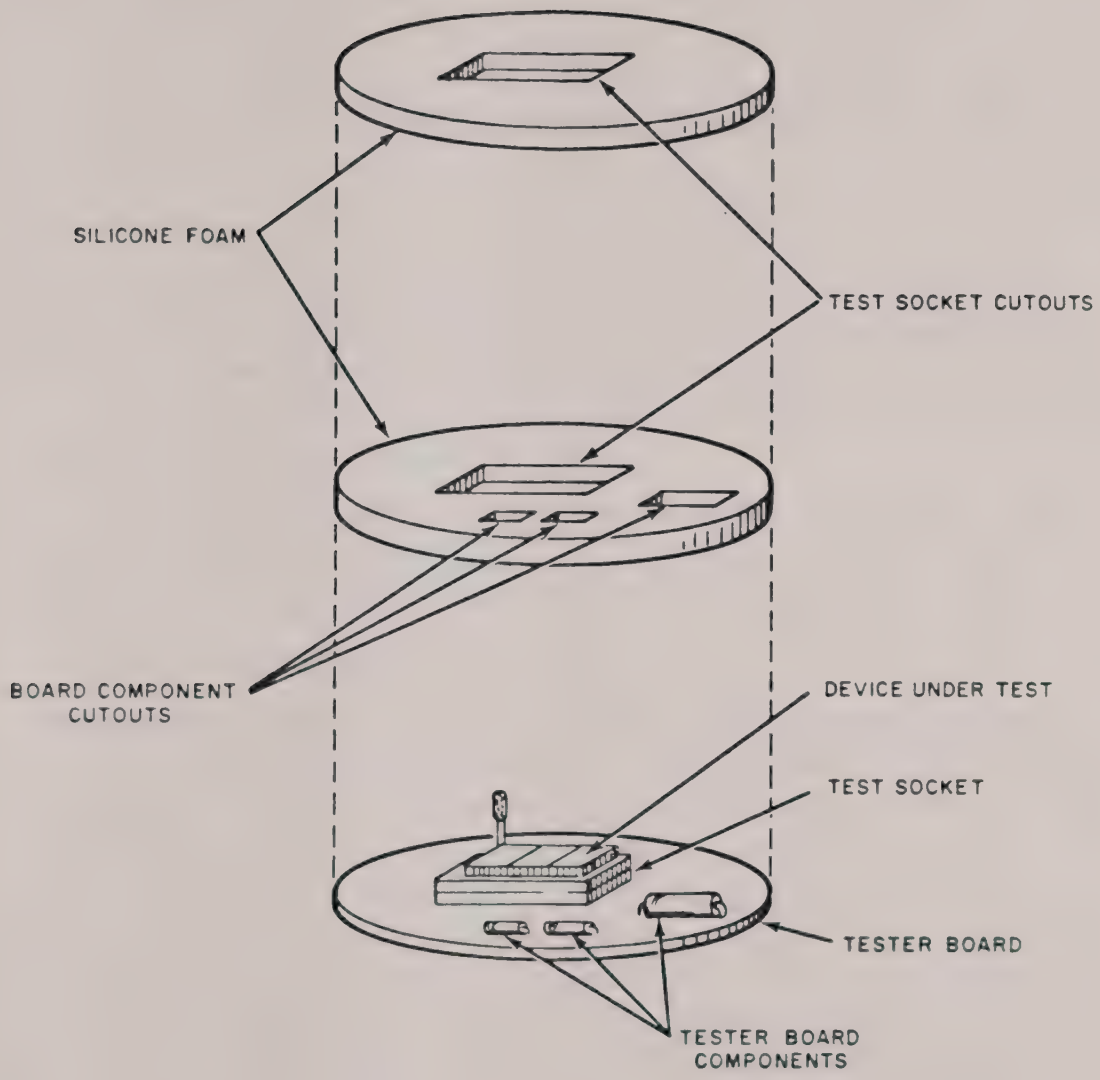


Figure C-1. Typical foam/board assembly.

APPENDIX D

MINIMIZING TEST SPECIMEN TEMPERATURE STABILIZATION TIMES

This Appendix outlines techniques that have proven helpful in shortening the time necessary to bring a test specimen to a stable test temperature and thus to increase the testing throughout. All the techniques discussed are applications of the physical principles discussed in Appendix B.

The following discussion includes both an explanation of each technique and ThermoStream test results of some of the techniques that illustrate the effect of applying each technique.

D.1 MINIMIZING THE TEST ZONE VOLUME

The glass thermocap supplied with a TP450 ThermoStream System has a volume of approximately 40 cubic inches. Yet a typical test specimen may have a substantially smaller volume. Normally, it is necessary to bring only the test specimen and the test fixturing to the test temperature. Thus, the provision of a small chamber which contains only these elements within the thermocap will reduce the volume and mass which are brought to temperature and should substantially reduce the time required for the test specimen to reach a stabilized test temperature, and should also reduce the difference between the ThermoStream air temperature and the test specimen stabilized test temperature.

To illustrate the validity of the above, a 40-pin ceramic DIP was tested, first using a TP450 system as manufactured and then repeating the test after enclosing the component and socket in a 1-inch x 5/8-inch x 2-3/4-inch plastic box. The bottom of the box was open to go over the component and socket, and the ThermoStream

nozzle was projected through the top of the box. A thermocouple soldered to the bottom of the component was used to measure component temperature. The results are given in Table D-1.

Table D-1. Results of tests using a reduced test zone volume.

Condition	Component Temperature Change	Thermo-Stream Air Temperature	Component Stabilization Temperature	Time in Seconds for Component to Reach Stabilization Temperature ±1°C
Without Inner Chamber	+25°C to -55°C +25°C to +125°C	- 59°C +129°C	- 55°C +125°C	186 202
With Inner Chamber	+25°C to -55°C +25°C to +125°C	- 56°C +126°C	- 55°C +125°C	100 80

D.2 USE OF TWO TEMPERATURE TEST SEQUENCE

The greater the difference between the ThermoStream air temperature and the test specimen temperature, the higher the rate of heat transfer between the two. Also, the greater the rate of heat transfer, the faster the temperature of the test specimen will change.

Thus, when a ThermoStream is used to change a test specimen temperature, a maximum rate of temperature change is achieved if the following sequence is followed:

1. Set the temperature controlled gas to a safe (to test specimen) temperature beyond the control temperature desired.
2. Maintain the gas temperature set in step 1 until the test specimen reaches the control temperature.
3. Change the gas temperature to the temperature necessary to maintain the test specimen at the control temperature.

Using the test setup described in Section D.1 (with the inner chamber in place), the results given in Table D-2 were achieved and illustrate the "Two Temperature Test Sequence."

Table D-2. Results of Two Temperature Test Sequence.

Component Temperature Change	Step 1 Set Temperature	Step 2 Set Temperature	Time in Seconds for Component to Reach Stabilization Temperature $\pm 1^{\circ}C$
$+25^{\circ}C$ to $-55^{\circ}C$	$-65^{\circ}C$	$-56^{\circ}C$	92
$+25^{\circ}C$ to $+125^{\circ}C$	$+150^{\circ}C$	$+126^{\circ}C$	50

It should be noted that these results exhibit a further improvement over the results of Section D.1.

D.3 FIXTURE PRESOAK

When testing at temperatures above the ambient air dew point temperature, the time necessary to change the test specimen temperature to the test temperature can be shortened if the fixturing in the test zone is left at the test temperature rather than returned to room temperature after each test. In this mode of operation, only the test specimen temperature requires changing and thus the temperature stabilization time can be shortened. Results of tests conducted in this manner are given in Table D-3.

Table D-3. Results of tests in which test fixturing remained at test temperature.

Component Temperature Change	Socket Temperature at Start of Test	Step 1 Set Temperature	Step 2 Set Temperature	Time in Seconds for Component to Reach Stabilization Temperature $\pm 1^{\circ}C$
+25 to $125^{\circ}C$	$+125^{\circ}C$	$126^{\circ}C$	$126^{\circ}C$	26
+25 to $125^{\circ}C$	$+125^{\circ}C$	$150^{\circ}C$	$126^{\circ}C$	15

D.4 PRESOAK

When testing specimens at temperatures above the dew point temperature of the ambient air, large groups of specimens can be held near the test temperature in a temperature chamber and transferred singly to the ThermoStream temperature controlled zone for testing at an accurate controlled test temperature. This will shorten the time necessary to bring the specimen to the test temperature.

NOTE

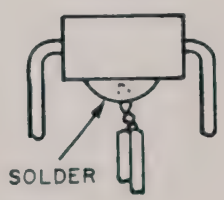
The modes of operation described in Sections D.3 and D.4 may be possible at some test temperatures below room temperature. However, condensation of moisture on the cold test fixture may preclude these modes of operation, or it may limit their use to a small number of cycles. Users will have to determine by electrical test in their specific applications if these are viable operating modes.

APPENDIX E

TEST SPECIMEN TEMPERATURE MEASUREMENT

This appendix discusses techniques of attaching thermocouples to test specimen cases. Proper thermocouple attachment is necessary for accurate temperature measurements, which in turn are necessary to determine test specimen temperature stabilization times (see Appendix D).

When mating test specimen thermocouples, do not use thermocouple wire thicker than No. 36 gauge (0.005 inch/0.013 mm). Thicker wires will conduct excessive heat between the test specimen and the ambient, resulting in inaccurate temperature measurements. The following examples show methods for thermocouple attachment to solderable and nonsolderable test specimens.

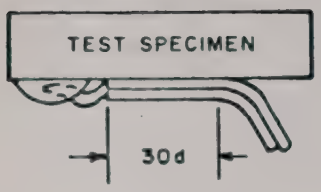


Unsatisfactory

Measures temperature at "A"
(Wires first join at "A")

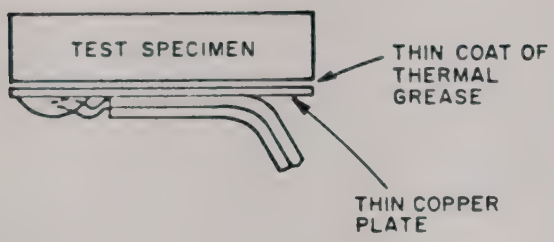
Improvement No. 1

Measures temperature at surface but thermocouple wire may conduct some heat from or to ambient.



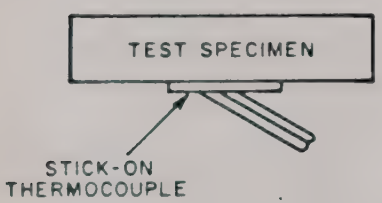
Improvement No. 2

Thermocouple wire is in contact with the surface to be measured for a length of at least 30 times the diameter of the thermocouple wire.



Alternative No. 1

Where soldering to the surface is either impossible or undesirable, a thin copper plate and a film of thermal grease act as a thermal path between thermocouple junction and component surface.



Alternative No. 2

Adhesive-backed thermocouple assemblies are available that meet the criteria for accurate temperature measurements. Examples of such thermocouples are given in Appendix F.

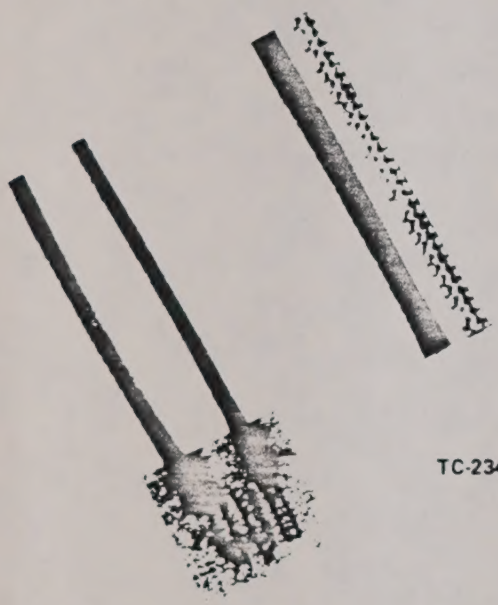
APPENDIX F

MINIATURE THERMOCOUPLES FOR SURFACE TEMPERATURES

MINIATURE ZIG/ZAG THERMOCOUPLES

FOR SURFACE TEMPERATURES

TC-2345 SERIES



TC-2345-P

TC-2345-D

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Surface Temperatures in the ELECTRONICS INDUSTRY . . .
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Switches
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Boilers
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Motors
Generators

See PD-546-1 for Additional ZIG/ZAG Thermocouples

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- EASILY ATTACHED TO SMALL SURFACES
- FROM -320° F TO +850° F
- FAST RESPONSE - HIGH ACCURACY
- FINGER-TIP MOUNTING
- AVAILABLE FOR TYPES J, K, T, & E
- "NO-LIE" JUNCTION